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NORTH OF ENGLAND INSTITUTE OF MINING ENGINEERS.

TRANSACTIONS.

VOL. IX.

1860-61.

NEWCASTLE-ON-TYNE: ANDREW REID, 40 & 65, PILGRIM STREET.

1861.

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NEWCASTLE-UPON-TYNE:
PRINTED BY ANDREW REID, 40 & 65, PILGRIM STREET.

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ADVERTIZEMENT.

THE Institution is not, as a body, responsible for the facts and opinions advanced in the Papers read, and in the Abstracts of the Conversations which occurred at the Meetings during the Session.

Report.

In presenting their Report of the position and proceedings of the Institute of Mining Engineers of the North of England to the General Meeting, the Council have a mingled and chequered duty to perform.

They have to congratulate their associates in this Institute upon a position of general prosperity, as far as the general objects of the association are concerned; at the same time they have to deplore losses by death, too sad to be psssed over without the expression of deep sorrow, and too considerable not to give rise to feelings of deep regret.

Speaking in general terms, the progress of the Society during the year just passed has been eminently satisfactory. The number of members, deducting the losses by death and other circumstances, has risen from 237 to 286 whilst the attendance at the monthly meetings, and the character of the papers read, and for many parts of the published "Transactions," have fully borne out the original intention and the general anticipated success and utility of the Institute.

The pecuniary position of the association will be detailed in the Treasurer's Statement of Account, embodied in the report of the Finance Committee.

The papers read during the past year have, without exception, been of an eminently practical character, and some of them treating of matters of very considerable interest.

An enumeration of them will sufficiently demonstrate this.

At the meeting of October the 4th, a paper "On Coke Ovens and their Construction" was read by Mr. A. L. Steavenson, which gave rise to a good deal of practical and useful discussion.

On November 1st, Mr. Stephen C. Crone read a paper "On Pillar Working," a subject already broached by Mr. Wm. Spencer, Jun., and one prolific also of considerable utility.

At the same time, a supplementary paper "On the Construction and Management of Coke Ovens" was produced by Mr. Steavenson.

On the 7th of February, a short explanatory paper "On the use of Cement for Walling as a substitute for Metal Tubbing in Shafts," was read by Mr. Watson, and at the same time, an essay "On Ventilating Furnaces and their Elasticity of Action," by Mr. Wm. Armstrong.

On the 7th March, a succint account was communicated by the President, of the facts connected with an explosion at Hetton Colliery, which appeared to have originated at the boiler flue of an underground engine called "Davison's Engine," which occasioned, by its destructive effects, a great loss of life and destruction of property, and which was very difficult to be accounted for under ordinary circumstances of underground engines. To the statement of facts was appended a copy of the evidence taken at the inquest. By the singular circumstances connected with this lamentable casuality a subsequent discussion of much curious interest was elicited, which is recorded in the proceedings.

At the same meeting, Mr. John Daglish read a paper containing additional observations "On the Construction of Ventilating Furnaces."

At the meeting of May the 2nd, a paper, by Mr. J. J. Atkinson, Inspector of Coal Mines, "On the Strength of Tubbing in Shafts, and the Pressure of Forces it has to resist," was read. This was a paper also of great practical as well as theoretical interest.

At the same meeting, a paper was read by the Treasurer, Mr. Boyd, "On a part of the Carboniferous Mountain Limestone Series of North Northumberland," which is the concluding paper published in the volume of the "Transactions" of the twelve months now ended, and which treats in a very able manner of the geology of a most interesting district.

From the pleasing duty of thus detailing the "Transactions" of the current year, the Council have for an instant to advert to a topic which painfully contrasts therewith. They have already mentioned the losses which death has occasioned this Society in the course of twelve months. It now becomes their duty merely to say, that memoirs of the leading events of the career of the late eminent and scientific vice-president, Joseph Locke, and of that of his colleague as a vice-president of this Institute, the late talented and accomplished Thomas John Taylor, will be found at pages 56 and 237 of the "Transactions" of the year, as read by the President, who was an intimate friend and well able to appreciate the acquirements of both of these distinguished and lamented men.

Having adverted to the leading "Transactions" of the past year, the Council may now be permitted to hazard a few observations on some topics of more remote or minor importance connected with the Institution.

The members of the Institute need not be reminded on this occasion of the various steps that have been taken, and efforts made by those appointed for that purpose, towards the establishment in some favourable and central locality of a practical Mining College, in which mine engineering, and the sciences immediately connected with it, might be taught.

It has not been the fault of those to whom the advancement of this desirable object was entrusted that their endeavours have been hitherto unsuccessful.

They have, however, much pleasure in communicating to the Institute their hopes that an opportunity may soon be presented for the realization of that desirable object.

This opportunity will be found in the Commission now appointed by Parliament to enquire into and amend the constitution and management of the University of Durham, especially with reference to the introduction into that seminary of the promotion and cultivation of practical knowledge.

At page 88 of the "Transactions" of the year will be found a memorial to Sir George Cornewall Lewis, the Secretary of State for the Home Department, with respect to this proposed enquiry, and strongly advocating the necessity, in a national point of view, of the incorporation with that University of a College for the advancement and teaching of Mining Science. The memorial was presented to the Home Secretary by a deputation headed by the President, who earnestly urged upon his consideration the various points embodied in the memorial connected with this important subject, to which Sir G. C. Lewis appeared to pay marked attention, and, without pledging himself to any definite conclusion, said the memorial should have his most serious consideration; recommending, in addition, that the subject should be laid before the proposed Commission. The Council accordingly beg to recommend that the President, with Messrs. J. T. Woodhouse and I. L. Bell, be appointed to give evidence before the Commission on the subject, with power to add to their number.

There yet remains one other topic to which it is the duty of the Council particularly to advert.

The Finance Committee have, in their Report already printed, and in

the possession of the members of the Institute, animadverted, and not without cause, on a growing insufficiency of room for the models, maps, library, and fossil specimens belonging to the Society, and on the necessity of some arrangement which may, either now or at some early period, obviate these inconveniences.

With a view to these very proper considerations, the Council may remark that a proposal has already been laid before a sub-committee appointed to receive it; such proposal emanating from the Natural History Society, whose premises communicate with the building at present occupied by the Institute, and who propose to mature some arrangement by which the valuable assortment of fossil specimens collecting and collected by this Institute may be made generally useful, not only to themselves but also to the public, by arranging them and exhibiting them in company with the fossil collection belonging to the Natural History Society.

An outline of the plan proposed by the Natural History Society was handed in by Messrs. Hancock and Mennell and by Dr. Charlton, who formed the deputation from the body of the members of that society; and such plan is now under the consideration of the Committee to whom the subject was referred. When the Committee shall have made its report, it will be the province of a general meeting to consider and determine what further steps shall be taken, and if it be practicable that such arrangments can be made which will accomplish the objects which the Institute have in view with reference to this important subject.

The next subject which the Council has to lay before the Institute for its consideration is the question—Is it desirable to appoint another secretary as recommended in the Finance Committee's report of August, 1860? The Council would refer to the proceedings thereon at the meeting of June last, and the resolution passed at that meeting, that the Council should report thereon to the annual meeting of this year. In pursuance of such resolution the Council beg to report as follows

That in their opinion the office of secretary requires revision, so that all the duties of that office, not considered as included in the duties of their present secretary, be efficiently performed.

In conclusion, the Council have to advert to the meeting which has recently taken place at Birmingham. It is not necessary for them to enter into detail of the preliminary proceedings taken with respect thereto, as these are alluded to in the proceedings of the monthly meetings. The Council would, however, beg to congratulate the Insti-

tution upon the eminent success of that movement, and of that meeting; and to express their entire conviction that the result will be most advantageous to the character and success of the Institution.

Besides the Address of the President, on "The Objects and Labours of the Institute," the following papers were read and discussed:— Mr. Samuel Bailey, on "Underground Engines, &c.;" Mr. T. Y. Hall, on "The Rivers, Ports, and Harbours of the Northern Coal-field;" Mr. Robert Ayton, on "Safety Cages;" Messrs. G. C. Greenwell and H. Cossham, on "The Somerset Coal-field;" Mr. J. T. Woodhouse, on "The Progress of Mining Engineering in the Derbyshire Coal-field, with a short Account of the Method of working Coal by Long-wall;" Mr. Stuart Smith, on "The Winning and Working of the Cinderhill Colliery;" Mr. George Fowler, on "Working the Main Seam at Moira, particularly with reference to Spontaneous Combustion;" Messrs. J. J. Atkinson and John Daglish, on "The Friction of Anemometers;" Mr. Henry Johnson, of Dudley, on "Working in the Thick Coal;" Mr. P. S. Reid, on "Boring through Quicksands."

There were, besides, eight other papers presented for reading, which were not read in conseqence of the want of time, but which, it is trusted, will be brought forward at the future meetings of the Institute.

The reading of the papers occupied two days, and on the third day several places in the neighbourhood were visited by the members and their friends; and it is only right to add, that the reception which the members and their friends met with from the Mayor and inhabitants of Birmingham, and from the proprietors of the various works they visited, was of the most enthusiastic character.

As the volume of the "Transactions" of the present year will be fully occupied by the papers read and discussed at Newcastle, the Council would recommend that the papers and transactions of the meeting at Birmingham be arranged in a separate volume.

Finance Report.

We beg to submit the Treasurer's Annual Accounts to the Institute, made up in accordance with resolution of the members, to the 31st July, 1861.

The total receipts of the Society from all sources has been as follows :—

Subscriptions from Members - - - -	£483	0	0
Do. from Collieries - - - -	73	10	0
From Sale of Publications - - - -	82	10	10
„ Interest on R. Stephenson, Esq.'s Legacy -	42	12	0
Legacy from R. Stephenson, Esq. - - -	2000	0	0
	2681	12	10
The Cash Balance in hand at close of 1860 was	273	11	0
	2955	3	10
The aggregate Payments, as per Balance Sheet, have been - - - - - - -	729	7	9
Leaving Cash in hands of Treasurer - -	£2225	16	1

We have to observe that the amount of £300 in the hands of the District Bank Liquidators remains unpaid, together with interest, which we suppose will be due on it.

The Maps of the Geological Survey, as recommended in last year's report, have been purchased.

With reference to the arrangement of Instruments, Models, Geological

Specimens, &c., alluded to in last year's report, your Committee beg to refer the Institute to their report to the Council in February last, and discussed at the June meeting.

The stock of books in the hands of the printer have been examined, and we believe the statement to be correct.

In furtherance of the resolutions of the June meeting, 269 complete volumes of the Proceedings of the Institute have been bound up.

P. S. REID.
JOHN R. LIDDELL.
CUTH. BERKLEY.

THE TREASURER IN ACCOUNT WITH THE NORTH

For the Year from August 1st, 1860,

1860.	Dr.	£	s.	d.
July 1.—To Balance in hand of Treasurer from Eighth Year	£273 11 0			
Do. being Proportion of Deposit at District Bank yet unpaid	300 0 0			
		573	11	0
„ Subscriptions collected since Balancing at July 31, 1860, for that and former years		37	16	0
„ Bequest of the late Robert Stephenson, Esq.		2000	0	0
„ Interest on Ditto, from Nov. 14, 1860, to June 30, 1861		42	12	0
„ Subscriptions from 212 Members		445	4	0
„ Subscriptions from Colliery Owners, viz.:—				
Black Boy	£4 4 0			
East Holywell	2 2 0			
Holywell Main	2 2 0			
Haswell	8 8 0			
Hetton	10 10 0			
North Hetton	6 6 0			
Grange	2 2 0			
Kepier Grange	2 2 0			
Lambton	10 10 0			
Leasingthorne	2 2 0			
Westerton	2 2 0			
Poynton and Worth	2 2 0			
South Hetton and Murton	8 8 0			
Stella	2 2 0			
Whitworth, for the Years 1858–59–60–61	8 8 0			
		73	10	0
By Sales of Publications, per A. Reid, from July 14, 1860, to and with January 31, 1861	£62 10 10			
„ Ditto, from January 31 to July 1	20 0 0			
		82	10	10
		£3255	3	10

OF ENGLAND INSTITUTE OF MINING ENGINEERS,

to and with July 1st, 1861.

1861.	Cr.	£	s.	d.
July 1.—By paid A. Reid, Printing and Publishing Account from July 14, 1860, to January 4, 1861....	£227 16 0			
,, Ditto, from January 4 to July 1	285 17 0			
,, Ditto, for Binding Copies of Vols. I., IV., and VIII.	39 16 0			
		553	9	0
,, Paid Postage Stamps, Secretary.....	17 10 2			
,, Do. and Receipt Stamps, Treasurer	5 7 9			
,, Do. Stamps, Printer.....	26 16 9			
		49	14	8
,, Paid for Circulars, Covers for Parts, &c.....		22	9	9
,, Paid for Advertising		14	3	6
,, Secretary's Salary, 11 Months up to July 1st		22	18	4
,, Reporter's ditto ditto		11	11	0
,, Paid H. Cossham for 50 Copies of Bristol Mining School Lectures		5	0	0
,, Paid P. S. Reid for a Work entitled "Charbon de Terre"....		5	5	0
,, Paid E. Stanford for Geological Maps and Sections		40	12	6
,, Paid R. Snowdon for Framing Robert Stephenson's Portrait..		1	17	6
,, Paid Premium for Insurance of £300 on Property at Institute Rooms.....		0	16	6
,, Paid Premium for Insurance of £400 on Property called Stock		1	10	0
,, Deposit Receipt held on Messrs. Lambton & Co. for Amount of the late Robert Stephenson's, Esq., Legacy £2000 0 0				
,, Balance in hand of Treasurer at this date	225 16 1			
,, Do. being Proportion of Deposit in hands of District Bank Liquidators yet unpaid	300 0 0			
	—2525	16	1	
	£3255	3	10	

GENERAL STATEMENT, JULY, 1861.

1861.	Liabilities.	£	s.	d.

1861.	Assets.	£	s.	d.
July 1.	By Amount of Cash in hands of Treasurer £225 16 1			
„	Ditto ditto District Bank Liquidators 300 0 0			
„	Ditto ditto Lambton and Co., and for which Deposit Receipt is held 2000 0 0			
		2525	16	1
„	Value of Volumes Bound	170	0	0
„	Sheets and Plates belonging to Vols. IV., VI., VII., and VIII.—Vols. I., II., III., and V. being now imperfect or bound	260	0	0
„	30 Copies of Mr. Wales' Paper on Ventilation..	3	15	0
„	Members' Subscriptions in Arrear at this date..	117	12	0
„	Sheets and Plates belonging to Vol. IX., unfinished at this date	125	0	0
		£3202	3	1

Patrons.

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The Right Honourable the Earl of Lonsdale.
The Right Honourable the Earl Grey.
The Right Honourable the Earl of Durham.
The Right Honourable Lord Wharncliffe.
The Right Honourable Lord Ravensworth.
The Right Reverend the Lord Bishop of Durham.
The Very Reverend the Dean and Chapter of Durham.
The Venerable Archdeacon Thorpe, the Warden of Durham University.
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81 Day, J. W., Newton Hall, Durham.
82 Deane, John, Tranent, North Britain.
83 Dees, J. Whitehaven, Cumberland.
84 Dennis, Henry, Byn yr Owen, South Wales.
85 Dixon, George, Whitehaven, Cumberland.
86 Dobson, S., Cardiff, South Wales.
87 Dodd, Benj., Blaenaron, Newport, Monmouthshire.
88 Douglas, T., Pease's West Collieries, Darlington.
89 Dumolo, J., Danton House, Coleshill, Warwickshire.
90 Dunn, T., Richmond Hill, Sheffield, Yorkshire.
91 Dunn, Thomas, C.E., Winden Bridge Works, Manchester, Lancashire.

92 Easton, J., Hebburn Colliery, Gateshead.
93 Elliot, G., Houghton-le-Spring, Fence Houses.
94 Elliott, W., Weardale Iron Works, Towlaw, Darlington.

95 Embleton, T. W., Middleton Hall, Leeds, Yorkshire.
96 Errington, ——, C.E., Westminster, London, S.W.

97 Fletcher, Jos., C.E., Dawson Place, Whitehaven, Cumberland.
98 Fletcher, John, Clipton Colliery, Manchester, Lancashire.
99 Foord, J. B., General Mining Association Secretary, 52, Broad Street, London.
100 Forster, J. H., Old Elvet, Durham.
101 Forster, G. B., Cowpen Lodge, Blyth.
102 Forster, Thomas E., 7, Ellison Place, Newcastle-on-Tyne.
103 Fowler, George, Moria Collieries, Ashby-de-la-Zouch, Leicestershire.
104 Fryar, Mark, Eighton Moor Colliery, Gateshead.

105 Gainsford, William Dunn, Derby, Derbyshire.
106 Gardner, M. B., Chilton Colliery, Ferry Hill.
107 Gillett, F. C., Derby, Derbyshire.
108 Gilroy, G., Orrell Colliery, Wigan, Lancashire.
109 Gooch, G., Lintz Colliery, Gateshead.
110 Green, G., Rainton Colliery, Fence Houses.
111 Greene, Jun., Wm., Framwellgate Colliery, Durham.
112 Greener, W., Pendleton, Wigan, Lancashire.
113 Greenwell, G. C., Radstock Colliery, Bath, Somersetshire.

114 Haggie, P., Gateshead.
115 Hall, T. Y., Eldon Square, Newcastle.
116 Hall, William, Page Bank Colliery, Crook, Darlington.
117 Hall, Thomas, West Hetton Colliery, Ferry Hill.
118 Hann, W., Hetton, Fence Houses.
119 Harden, J. W., Exhall Colliery, Coventry, Warwickshire.
120 Hardy, Benj., Woodhouse Close Colliery, Durham.
121 Harris, C.E., Jno., Woodside, Darlington.
122 Harrison, C.E., T. E., Central Station, Newcastle.
123 Hawthorn, R., Engineer, Newcastle.
124 Hawthorn, W., Engineer, Newcastle.
125 Heath, Robert, Newcastle-under-Lyme, Staffordshire.
126 Heckels, R., Bunker's Hill, Fence Houses.
127 Hedley, Edward, Gresley Wood Colliery, near Burton-on-Trent.
128 Herdman, John, High Horton, Blyth.

129 Hetherington, David, Howard's West Hartley Colliery, Netherton, near Morpeth.
130 Hewlett, Alfred, Ince Hall Coal Works, Wigan, Lancashire.
131 Higmore, Jacob.
132 Hodgson, R., Engineer, Whitburn, Monkwearmouth, Sunderland.
133 Hood, Archibald, Whitehill Colliery, Lasswade, Edinburgh.
134 Horsley, Jun., W., Seaton Cottage, Hartley, Newcastle.
135 Howard, ——, Staveley Works, Chesterfield, Derbyshire.
136 Hunt, J. P., Corngreaves, Birmingham, Warwickshire.
137 Hunter, Wm., Spital Tongues, Newcastle.
138 Hurst, T. G., Backworth Colliery, Newcastle.

139 Jackson, Frederick John, Seaton Delaval, Newcastle.
140 Jackson, Henry, Astley Colliery, Manchester, Lancashire.
141 Jackson, John, Derby, Derbyshire.
142 James, Christopher, Mountain Ash Colliery, Aberdare.
143 Jeffcock, P., Midland Road, Derby.
144 Jobling, T. W., Point Pleasant, Wallsend, Newcastle.
145 Johnson, G., Talk'oth Hill, Lawton, Cheshire.
146 Johnson, J., Chilton Hall, Ferry Hill.
147 Johnson, R. S., West Hetton, Ferry Hill.
148 Joicey, James, Quay, Newcastle.
149 Joicey, John, Tanfield Lea, Gateshead.
150 Jones, E., Lilleshall Iron Works, Sheffnal, Salop,
151 Jones, Alexander, Mine Agent, Prior's Lea, near Sheffnal, Shropshire.

152 Kerr, John, Hamilton's Gas Coal Works, Lismahagow, North Britain.
153 Kimpster, W., Quay, Newcastle.
154 Knowles, A., Crescent, Salford, Manchester, Lancashire.
155 Knowles, John, Pendlebury, Manchester, Lancashire.
156 Knowles, Thomas, Ince Hall, Wigan, Lancashire.

157 Lancaster, John, Hindley Hall, Wigan, Lancashire.
158 Landale, Andrew, Lochgelly, Fifeshire, North Britain.
159 Laverick, George, Plymouth Iron Works, Merthyr Tydvil, Glamorganshire.

160 Laws, J., Blyth, Northumberland.
161 Ledward, William J., South Bank Iron Works, Eston Junction, Middlesbro'-on-Tees.
162 Levick, Jun., F., Cwm Celyn, Blaina and Colebrook Dale Iron Works, Newport, Monmouthshire.
163 Lewes, T. Wm., Plymouth Iron Works, Merthyr Tydvil, Glamorganshire.
164 Liddell, J. R., Netherton Colliery, Morpeth.
165 Liddell, M., Hedgefield House, Stella, Gateshead.
166 Lindop, James, Bloxwich, Walsal, Staffordshire.
167 Lishman, Wm., Etherley Colliery, Darlington.
168 Lishman, Wm., Lumley Colliery, Fence Houses, Durham.
169 Little, William, West Cramlington, Newcastle.
170 Livesey, Thos., Chamber Hall, Hollingwood and Bradford Colliery, Manchester, Lancashire.
171 Llewellin, Wm., Glanwern, Pontypool, Glamorganshire.
172 Longridge, J., 18, Abingdon Street, Westminster, London, S.W.
173 Love, Joseph, Brancepeth Colliery, Durham.
174 Low, Wm., Vron Colliery, Wrexham, Denbighshire.

175 Marley, John, Mining Offices, Darlington.
176 Maddison, W. P., Thornhill Lees Colliery, Wakefield.
177 Marshall, Robt., Lugar Iron Works, Ayrshire, North Britain.
178 Matthews, Richd., South Hetton Colliery, Fence Houses.
179 Matthews, Philip, Leasowes, Staffordshire.
180 Mc'Ghie, Thos., British Iron Works, Ruabon, Denbighshire.
181 Mercer, J., St. Helens, Lancashire.
182 Middleton, J., Davison's Hartley Office, Quay, Newcastle-on-Tyne.
183 Morris, Wm., Waldridge Colliery, Chester-le-Street, Fence Houses.
184 Morton, H., Lambton, Fence Houses.
185 Morton, H. J., Garforth House, Leeds, Yorkshire.
186 Morton, H. T., Lambton, Fence Houses.
187 Muckle, John, Little Town Colliery, Durham.
188 Mulcaster, H., Colliery Office, Whitehaven.
189 Mulvany, Wm. Thos., 1335, Carls Thor, Dusseldorf on the Rhine, Prussia.
190 Mundle, W., Ryton, Gateshead.
191 Murray, T., Chester-le-Street, Fence Houses.
192 Murray, T. H., Chester-le-Street, Fence Houses, Durham.

193 Napier, Colin, Westminster Colliery, Wrexham, Denbighshire.

194 Palmer, A. S., Malago Vale Colliery, Bedminster, Bristol.
195 Palmer, C. M., Quay, Newcastle-on-Tyne.
196 Palmer, J. B., Jarrow, South Shields.
197 Paton, Wm., Alloa Colliery, Alloa, North Britain.
198 Peace, Maskel Wm., Solicitor, Wigan, Lancashire.
199 Pearce, F. H., Bowling Iron Works, Bradford, Yorkshire.
200 Pease, J. Wm., Woodlands, Darlington.
201 Peele, John, Springwell Colliery, Gateshead.
202 Pilditch, Wm., Iron Shipbuilding Yard, Jarrow, South Shields.
203 Pilkington, Jun., Wm., St. Helens, Lancashire.
204 Potter, E., Cramlington, Newcastle-on-Tyne.
205 Potter, W. A., Mount Osborne Collieries, Barnsley, Yorkshire.
206 Powell, T., Newport, Monmouthshire.

207 Ramsay, J., Walbottle Colliery, Newcastle-on-Tyne.
208 Ramsay, David R., Iron Works, Wallsend.
209 Ravenshaw, J. H., Seaham Harbour, Fence Houses.
210 Reed, R. G., Newton Colliery, Felton, Northumberland.
211 Rees, Robt. T., Lothy, Shenkin Colliery, Aberdare, Glamorganshire.
212 Reid, P. S., Pelton Colliery, Chester-le-Street, Fence Houses.
213 Richardson, Dr., Framlington Place, Newcastle-on-Tyne.
214 Robinson, R., Stanley Colliery, Pease's West, Darlington.
215 Robson, J. G., 38, King William Street, London.
216 Robson, G., Tondû Iron Works, Bridge End, Glamorganshire.
217 Robson, M. B., Field House, Borough Road, Sunderland.
218 Robson, Thomas, Wylam Colliery, Newcastle-upon-Tyne.
219 Rockwell, Alfd. P., M.A., Norwich, Connecticut, United States, America.
220 Rogers, E., Abercarne Colliery, Newport, Monmouthshire.
221 Ross, A., Shipcote Colliery, Gateshead.
222 Rosser, Wm., Mineral Surveyor, Llanelly, Carmarthenshire, Wales.
223 Routledge, Jun., Wm., Shincliffe Colliery, Durham.
224 Rutherford, J., South Tyne Colliery, Haltwhistle, Northumberland

225 Sanderson, Jun., R. B., West Jesmond, Newcastle-on-Tyne.
226 Sawyers, W. G., Whitehaven, Cumberland.
227 Shepperdson, Edw. H., Hermitage, Chester-le-Street.

228 Shortreed, T., Newbottle Colliery, Fence Houses.
229 Shore, Isaac, Mineral Surveyor, Brymbo, near Wrexham, Denbighshire.
230 Shute, Charles A., Thornley Vicarage, Ferry Hill.
231 Simpson, L., Medomsley Colliery, Durham.
232 Simpson, R., Ryton, Newcastle.
233 Simpson, John Bell, Moor House, Ryton, Newcastle.
234 Simpson, R. L., Western Hill, Durham.
235 Sinclair, E., Western Hill, Durham.
236 Smallman, Joseph Harris, King's Hill, Wednesbury.
237 Smith, C. F. S., Cinder Hill, near Nottingham.
238 Smith, F., Bridgewater Canal Office, Manchester, Lancashire.
239 Smith, Jun., J., Monkwearmouth Colliery, Sunderland.
240 Smith, Edmund J., 14, Whitehall Place, Westminster, London, S.W.
241 Sopwith, T., Allenheads, 43, Cleveland Square, London, W.
242 Southern, G. W., Rainton Colliery, Fence Houses.
243 Southern, J. M., Kibblesworth Hall, Gateshead.
244 Spark, H. K., Darlington, County of Durham.
245 Spencer, Jun., W., Corporation Road, Middlesbro'-on-Tees.
246 Steavenson, A. L., Woodifield Colliery, Crook, Darlington.
247 Stenson, Jun., W., Whitwick Colliery, Ashby-de-la-Zouch, Leicestershire.
248 Stephenson, George, 24, Great George Street, Westminster, London, S.W.
249 Stobart, H. S., Witton-le-Wear, Darlington.
250 Stobart, Wm., Roker, Monkwearmouth, Sunderland.
251 Storey, T., St. Helen's Auckland, Bishop Auckland.
252 Stott, G., Ferry Hill, County of Durham.

253 Taylor, H., Earsdon, Newcastle-on-Tyne.
254 Taylor, M.P., H., Backworth Hall, Newcastle-on-Tyne.
255 Taylor, J., Earsdon, Newcastle.
256 Telford, W., Cramlington, Newcastle-on-Tyne.
257 Thomas, H. W., Pinchinthorpe, Northallerton, Yorkshire.
258 Thompson, John, Marley Hill Colliery, Gateshead.
259 Thompson, Jun., John, Marley Hill Colliery, Gateshead.
260 Thompson, T. C., Kirkhouse, Brampton, Cumberland.
261 Thorpe, R. C., North Gawber Colliery, Staincross, Barnsley, Yorkshire.

262 Tone, C.E., John F., Market Street, Newcastle-on-Tyne.
263 Trotter, J., Newnham, Gloucestershire.
264 Truran, Matthew, Dowlais Iron Works, Merthyr Tydvil, South Wales.

265 Vaughan, J., Middlesbro'-on-Tees.
266 Vaughan, Thos., Middlesbro'-on-Tees.
267 Vaughan, William, Middlesbro'-on-Tees.
268 Verner, Albert, Framwellgate Colliery, Durham.

269 Wales, T. E., Abersychan Iron Works, Pontypool, Monmouthshire.
270 Walker, J. Lakelock, Wakefield, Yorkshire.
271 Walker, Jun., T., High Street, Maryport, Cumberland.
272 Ware, W. H., The Ashes, Stanhope, Weardale.
273 Warrington, John, Rippax, near Leeds.
274 Watson, W., High Bridge, Newcastle-on-Tyne.
275 Watson, Joseph J. W., Ph. D. &c., The Knap, Charlton Kings, Cheltenham, Gloucestershire.
276 Webster, R. C., Ruabon Collieries, Ruabon, North Wales.
277 Willis, Jas., West Auckland Colliery, Bishop Auckland.
278 Wilmer, F., Framwellgate Colliery, Durham.
279 Wilson, J. B., Haydock Rope Works, Warrington, Lancashire.
280 Wilson, R., Flimby Colliery, Maryport, Cumberland.
281 Wilson, John Straker, Backworth Colliery, near Newcastle.
282 Wood, C. L., Black Boy Colliery, Bishop Auckland.
283 Wood, Lindsay, Hetton Colliery, Fence Houses.
284 Wood, N., Hetton Hall, Fence Houses, County of Durham.
285 Wood, W. H., Coxhoe Hall, Ferry Hill.
286 Woodhouse, J. T., Midland Road, Derby, Derbyshire.

List of Subscribing Collieries.

Owners of Stella Colliery, Ryton, Newcastle-on-Tyne.
„ Grange Colliery, Durham.
„ Kepier Grange Colliery, Ferry Hill.
„ Leasingthorne Colliery, Ferry Hill.
„ Westerton Colliery, Ferry Hill.
„ Poynton and Worth Colliery.
„ Holywell Main Colliery.
„ Black Boy Colliery, Bishop Auckland.
„ North Hetton Colliery, Fence Houses.
„ Haswell Colliery, Durham.
„ South Hetton and Murton Collieries, Fence Houses.
„ Earl of Durham, Lambton Collieries, Fence Houses.
„ Seghill Colliery, Seghill, near Newcastle.
„ East Holywell Colliery.
„ Hetton Collieries, Fence Houses.
„ Whitworth Colliery, Ferry Hill.

Rules.

1.—That the Members of this Society shall consist of Ordinary Members, Life Members, and Honorary Members.

2.—That the Annual Subscription of each Ordinary Member shall be £2 2s. 0d., payable in advance, and that the same shall be considered as due and payable on the first Saturday of August in each year.

3.—That all persons who shall at one time make a Donation of £20 or upwards, shall be Life Members.

4.—Honorary Members shall be persons who shall have distinguished themselves by their Literary or Scientific attainments, or made important communications to the Society.

5.—That a General Meeting of the Society shall be held on the first Thursday of every Month (except in January and July), at twelve o'clock noon, and the General Meeting in the month of August shall be the Annual Meeting, at which a report of the proceedings, and an abstract of the accounts of the previous year shall be presented by the Council. A Special Meeting of the Society may be called whenever the Council shall think fit, and also on a requisition to the Council signed by ten or more members.

6.—No alteration shall be made in any of the Laws, Rules, or Regulations of the Society, except at the Annual General Meeting, or at a Special Meeting; and the particulars of every alteration to be then proposed shall be announced at a previous General Meeting, and inserted in its minutes, and shall be exhibited in the Society's meeting-room fourteen days previously to such General Annual or Special Meeting.

7.—Every question which shall come before any Meeting of the Society shall be decided by the votes of the majority of the Ordinary and Life Members then present and voting.

8.—Persons desirous of being admitted into the Society as Ordinary or Life Members, shall be proposed by three Ordinary or Life Members, or both, at a General Meeting. The proposition shall be in writing, and signed by the proposers, and shall state the name and residence of the individual proposed, whose election shall be ballotted for at the next

following General Meeting, and during the interval notice of the proposition shall be exhibited in the Society's-room. Every person proposed as an Honorary Member must be recommended by at least five Members of the Society, and elected by ballot at the General Meeting next succeeding. A majority of votes shall determine every election.

9.—The Officers of the Society shall consist of a President, four Vice-Presidents, and twelve Members who shall constitute a Council for the direction and management of the affairs of the Society; and of a Treasurer and a Secretary; all of whom shall be elected at the Annual Meeting, and shall be re-eligible, with the exception of Three Councillors whose attendances have been fewest. Lists containing the names of all the persons eligible having been sent by the Secretary to the respective Members, at least a month previously to the Annual Meeting;—the election shall take place by written lists, to be delivered by each voter in person to the Chairman, who shall appoint scrutineers of the lists; and the scrutiny shall commence on the conclusion of the other business of the meeting. At meetings of the Council, five shall be a quorum, and the record of the Council's proceedings shall be at all times open to the inspection of the members of the Society.

10.—The Funds of the Society shall be deposited in the hands of the Treasurer, and shall be disbursed by him according to the direction of the Council.

11.—The Council shall have power to decide on the propriety of communicating to the Society any papers which may be received, and they shall be at liberty, when they think it desirable to do so, to direct that any paper read before the Society shall be printed. Intimation shall be given at the close of each General Meeting of the subject of the paper or papers to be read, and of the questions for discussion at the next meeting, and notice thereof shall be affixed in the Society's-room ten days previously. The reading of papers shall not be delayed beyond three o'clock, and if the election of members or other business should not be sooner despatched, the President may adjourn such business until after the discussion of the subject for the day.

12.—That the Copyright of all papers communicated to and accepted by the Institute, becomes vested in the Institute; and that such communications shall not be published for sale, or otherwise, without the permission of the Council.

13.—That the transmission of the Proceedings be withheld from members more than two years in arrear of their annual subscriptions.

ERRATA.

Page 149, six lines from bottom, *for* " water tank trass" *read* water tight trass.

Page 154, nineteen, twenty-two, and twenty-three lines from top, *for* "per hour" *read* per twenty-four hours, in each case.

NORTH OF ENGLAND INSTITUTE
OF
MINING ENGINEERS.

it would be well to determine this and to pass a resolution on the subject.

After some discussion, the following resolution was agreed to:—

"That the Council be requested to take into consideration, at their next meeting, the disposition of this sum, and report to a General Meeting, at the earliest opportunity.

The PRESIDENT referred to the sudden and lamented death of Mr. Joseph Locke, one of their Vice-Presidents. Mr. Locke was an old friend of his, having known him from the first commencement in his profession, indeed, he believed, his first employment in business was by

ERRATA.

In the discussion of Mr. Armstrong's paper "On Ventilating Furnaces, and their Elasticity of Action," Vol. IX., page 158, eight lines from the top, *for* "375·2°," *read* 459°; an error which gives rise to others, requiring the following corrections for their rectification :—

Page 158, twelve lines from the top, *for* "$t' = 375{\cdot}2° + 2t°$," *read* $t' = 459° + 2t°$.

,, fifteen lines from the top, *for* "439·2°," *read* 523°.

,, sixteen lines from the top, *for* "495·2°," *read* 579°.

NOTE.—The maximum draught is produced when the hot air in a chimney has exactly half the density of the outer air.

NORTH OF ENGLAND INSTITUTE

OF

MINING ENGINEERS.

GENERAL MEETING, THURSDAY, OCTOBER 4, 1860, IN THE ROOMS OF THE INSTITUTE, WESTGATE STREET, NEWCASTLE-UPON-TYNE.

NICHOLAS WOOD, ESQ., PRESIDENT OF THE INSTITUTE, IN THE CHAIR.

The SECRETARY read the minutes of the Council meeting, after which the gentlemen proposed for members at the last meeting were elected, viz., Mr. George Robert Stephenson, 24, George Street, Westminster; Mr. Wm. Pilditch, Iron Ship-building Yard, Jarrow; Mr. John Thompson, Jun., Marley Hill Colliery; Mr. Thomas Robson, mining engineer, Wylam Colliery; Mr. J. B. Simpson, Moorhouse, Ryton; Mr. Thos. Rymer Bourne, Peasley Cross Colliery, W. Helens; Mr. John Herdman, High Harlow, near Blyth.

The PRESIDENT said, Mr. Stephenson's bequest of £2,000 had been placed in the Messrs. Lambton & Co.'s bank, at bank interest. They could not make any other investment, until they knew what was to be done with it, whether there was to be any specific appropriation of it, or if it was to be merged into the general funds of the Society; perhaps it would be well to determine this and to pass a resolution on the subject.

After some discussion, the following resolution was agreed to:—

"That the Council be requested to take into consideration, at their next meeting, the disposition of this sum, and report to a General Meeting, at the earliest opportunity.

The PRESIDENT referred to the sudden and lamented death of Mr. Joseph Locke, one of their Vice-Presidents. Mr. Locke was an old friend of his, having known him from the first commencement in his profession, indeed, he believed, his first employment in business was by

himself, to make a survey for the late Lord Crewe, in Cheshire, of a coal mine, which he (the President) was engaged in reporting upon, and this was the first money Mr. Locke had earned. He was, therefore, intimately acquainted with him in early life, and, until the time of his death, indeed, he might say that acquaintanceship had never been interrupted. Mr. Locke was, as is well known, employed by the elder Stephenson in the early introduction of railroads, and was afterwards associated with Mr. Robert Stephenson in several important works, in the early period of railways. It was due, therefore, to the memory of that gentleman, as well on account of his having risen, as it were, from this district, concurrently with other celebrated engineers—from having done so much for railroads—and from his connection with this Institute, that some record of his eventful life and labours should be noticed in their Proceedings. His death had, however, so recently occurred, that he (the President) had not had time to prepare such a document. He would, however, with the permission of the Institute, do so, and lay it before them at as early a period as he could possibly accomplish such a task. After some further observations by the President, it was arranged, as being the unanimous wish of the gentlemen present, that the President should, at an early period, give the Institute an outline of the labours of their late Vice-President.

The PRESIDENT said, it would be in the recollection of the Institute that Mr. Locke was only elected a Vice-President in August last. He had communicated to him that event, but it appeared, that he had gone into Scotland to enjoy his annual relaxation from business, and that he had shortly afterwards been seized with that malady from which he never recovered. He had not, therefore, had an answer to his communication. It would, therefore, devolve upon them to elect another Vice-President, and he proposed that they should take the subject into their consideration at the next meeting.

The next subject on the minutes of the Council was the appointment of the Finance Committee. The Council recommended that Mr. P. S. Reid, Mr. Cuthbert Berkley, and Mr. John R. Liddell, should be the Finance Committee.

Mr. BERKLEY said the Council passed all the accounts before they were paid, so that the Finance Committee's duties were not well defined.

Mr. LIDDELL said some distinct duty should be assigned to the Finance Committee.

Mr. Berkley said, if an order were passed that the Treasurer should not pay any account unless it were first signed by two members of the Committee, they would then be enabled to exercise a proper control over the payments of the accounts of the Institute.

The following motion was then adopted, viz., "That two members, at least, of the Finance Committee, sign every account before payment thereof."

Mr. Reid said, at the annual meeting in August it was determined that the ordinary meetings should be held once a month. He wished to know why there was no meeting in September?

The Secretary—We relied on a paper of Mr. Boyd's being read, and he wrote to say that it was not ready. He (the Secretary) saw Mr. Potter and Mr. Thos. John Taylor, two of the Vice-Presidents, and they thought it best, under such circumstances, to take the responsibility, and not to have a meeting; and he got their permission to send a circular to adjourn it.

Mr. Reid said, according to rule there ought to have been a Council meeting on the Saturday, but no such meeting had been called. That meeting should have decided whether there was to be a postponement or not, and not any individual members.

The President said, it was very desirable that the regular routine of conducting the business of the Institute should be adhered to, and he had no doubt that such in future would be the case. Being September several members, himself amongst the number, were absent; the Secretary had done what he conceived was best under the circumstances, and he trusted in future that all would be regular.

MR. STEAVENSON'S PAPER ON COKE OVENS.

Mr. Steavenson, in answer to an enquiry by the President, said he had nothing to add to his paper, except with reference to a patent which had been taken out since his paper was read, which he would lay before the Institute at a subsequent meeting, and give drawings of that, as well as of some other coke ovens which he had not thought necessary to do at the time when his original paper was read, but which he now understood it was desirable to do.

Mr. Berkley then read the following remarks:—In looking over Mr. Steavenson's paper on the Manufacture of Coke, I would offer the following observations:—At page 110, line 12, vol. VIII., Mr. Steaven-

son says, in calculating the make of coke—"Foundries use a large quantity, every ton of metal brought down requiring about 200 lbs. of coke." This is a quotation from Dr. Ure's "Dictionary of Arts," &c.; but Mr. S. has, I think, come to an erroneous conclusion, for, if he had read a little further, he would have found his calculations materially altered. Dr. Ure proceeds thus—"After the cupola has been brought to its proper heat by the combustion in it of nine baskets of coke = 360 lbs." Those who are more versed in the working of foundries will be able to inform us what proportion this heating of the cupola bears to the quantity of metal brought down; but, in another place, Dr. Ure gives us the information himself, for he says—"In the course of a year a foundry will consume 300 tons of coke in melting 1240 tons of cast iron." It appears from this, that every ton of metal requires 463 lbs. of coke, instead of 200 lbs; making a total of 679,512 tons, instead of 293,526, as stated by Mr. S. From what source Mr. S. obtains the amount of metal "brought down" in foundries is not mentioned. I have assumed the quantity as correct, not having any data myself.

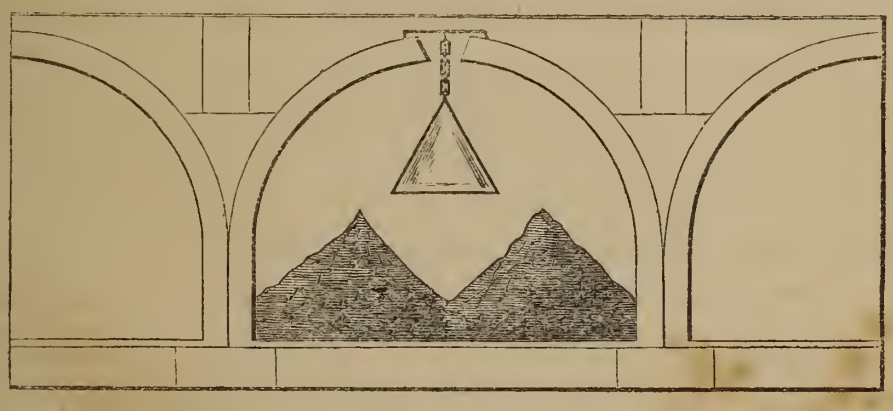
At page 114, in the first paragraph, Mr. S. says, after stating the means used for cooling the oven by throwing on water—"The only drawback from the latter method of cooling being the contact of water with the hot bricks." This, no doubt, is a very serious objection; but I have heard of another, and which, I think, to a certain extent, is correct, that when water is thrown upon the coke in the high state of temperature at which it must be when drawn at seventy-two and ninety-six hours, it renders the coke very friable, and, of course, of less commercial value.

On the same page, line 16, Mr. S. says, in reference to the oven taking fire—"Then follows a thick black smoke and reddish flame all round the sides." This, I think, is not always the case, and my experience tells me, that in good substantially-built ovens, if the "reddish flame" does not strike over the whole surface of the coal at once, that part most in the current of air is the first, and where the coal ignites round the sides of the oven, it does so before the oven strikes, as it is technically called, and in consequence of the fire passing from the adjoining oven by means of the small crevices occasioned by the contraction of the bricks in the oven that has just been loaded with coal, or merely from the heat of the side of the oven, in which latter case I have seen the coal round the sides take fire almost immediately after loading.

Then Mr. S. says—"Openings, as the oven increases in heat, extend

downward, so as to allow the volatile matters to pass off, and, by their ignition, generate additional heat." I believe these openings only extend downwards as the coal is coked, for if an oven is cooled out when it is only half burnt off, the basaltic form does not extend further down than where the coal is completely coked. Next the coke is a mass, extending over the whole oven, of charred coal cemented together; and below that will be found the coal in precisely the same state in which it was put into the oven. Of course, the line between these separate states is not distinct, but I think I am not far wrong when I say that the coke, in a perfect state, will be found not more than four inches above the coal, untouched by fire, the mass of charred coal lying between. I think in this Mr. S. will agree with me, if he has noticed it.

Mr. S., in the next paragraph, says—"As the process ceases, we have a bright, clear flame, which dies gradually off, lingering longest over the centre of the oven, owing to the smallest coal lodging there when loaded from the top and not properly levelled." This is, I believe, one of the greatest objections to loading the ovens from the top, so much depends upon the men in charge spreading the coals regularly; and even with those most careful, it is scarcely possible to have the coals of the same density over the whole oven. I have heard of a process adopted to avoid this greater density in the centre of the oven, but I have not seen it, and therefore cannot vouch for its efficiency, namely, a cone hung by means of a bar passed across the centre opening in the oven top, with its base downwards, thus—



so that the coals falling from the small wagon into the oven strike the cone, and are diverted from the centre, falling more lightly all over the oven.

In the next paragraph, I cannot altogether agree with the writer in that he says—"After all flame has ceased, the sooner the oven is drawn the better." In some cases, and with some descriptions of coal, this

may be correct; but generally, I think, the coke becomes more dense, and less liable to break into small pieces, if allowed to remain a few hours in the oven after the flame has left. If the air is carefully excluded, I think the quality of the coke would be improved by remaining twenty-four hours in the oven.

I quite agree with the writer as to the use of coke brees in preserving the coke near the inlet at the door, for, with many descriptions of coal, the burner, let him regulate the air as he will, cannot prevent this wasting or burning away of the coke; but this remedy has a drawback, for the brees or small coke often run to a scar or clinker, and if not carefully picked out, damages the quality of the coke for locomotive purposes.

With reference to the form and size of the oven—

(1.) I quite agree with Mr. Steavenson that a circular oven, ten and a half feet, or perhaps eleven feet diameter, has given most satisfaction. Ovens of a smaller diameter are not so expensive to maintain, but the quality of the coke produced is inferior. Again, ovens of a larger diameter produce a better quality of coke, but are much more expensive to maintain.

(2.) As to ovens with and without flues and chimneys, no one, I think, who has had experience with the former will ever recommend the latter, except where quality is not an object, and economy of first cost is a very great one; and I am of Mr. Steavenson's opinion in all he says upon that subject.

In loading the ovens, I advocate the coals being thrown in by hand at the door, rather than dropped by wagon in at the top of the oven, for the reason Mr. Steavenson states; and, further, I think the wagons passing over the top of the ovens will rather tend to shake them; but as I have not had experience with this class of oven, I cannot speak confidently as to which system is the best.

The President—Any admission of air into the ovens when in a state of great heat, and in cooling, oxidizes the coke, and, of course, wastes it.

Mr. Berkley—It spoils the coke; but if you can guard against this, the coke gets more dense the longer it is kept in the oven.

Mr. Dunn—Does it not lose weight when kept in the oven?

Mr. Berkley—With some descriptions of coal it does not.

The President—If you do not let the coke cool in the oven it must

be cooled by water; and if you throw the water hastily into the oven, when in a state of intense heat, it is apt to destroy the brick work; and when the coke is drawn out of the oven in a state of great heat, and before it is in a dense, compact state, and water is then thrown upon it, the coke becomes split and broken.

Mr. BERKLEY—That is so.

Mr. REID—Mr. Berkley makes it a condition that the air should be excluded altogether. Mr. Steavenson says, when every precaution is used, it is impossible to exclude it.

Mr. BERKLEY—It is not absolutely necessary to exclude all air.

The PRESIDENT—The affinity of the carbon, or coke in a state of red or white heat, for oxygen, makes the admission of air injurious, and very undesirable. When the coking process is complete, and air is then admitted, it flies off as dust.

Mr. BERKLEY—It is, to a certain extent, injurious.

The PRESIDENT—A perfect oven should be impervious to air, except at the openings. Air is admitted through these openings in the early part of the process. When the carbonization is complete, the openings are closed, and continue so whilst the coke is cooling down. I suppose it is a fact, that in a well-constructed oven, closed at the proper period, and allowed to cool quietly down, the coke is much harder than if water is thrown into the oven to cool it.

Mr. BERKLEY—I find, when the men are drawing ovens cooled with water at a great heat, the coke breaks to pieces very much.

Mr. REID—Are you able to tell us what is the maximum temperature in carbonization?

The PRESIDENT—That is, the temperature that will drive off the gaseous productions of the coal? I do not know of any experiments to ascertain this.

Mr. REID—I have heard it stated at something like 2000°.

Mr. BERKLEY—There is a difference in the different descriptions of coal.

Mr. REID—Before all the gaseous matter is driven off, and when coke is the only product, it must reach the maximum temperature, and then it gradually cools.

The PRESIDENT—The process of coking begins at the top of the coal, and proceeds gradually downwards to the bottom of the oven. The time of coking depends on the thickness of the coal, and the ultimate degree of heat will, in some respects, depend on the thickness of the coal likewise. If you have four feet of coal, the temperature will be

much higher than if there is only twelve inches. The condition of the coke also very much depends on the process. The deeper the coal, the denser the coke, owing, probably, to its being longer exposed to the heat. In the process of driving off the gases, and whilst the coking is going on, such gases pass upwards through the already carbonized portion of the coke, and such gases giving out carbon appear to render the portion of the coke, which it passes through, more dense and compact. This, I fancy, must be the reason why a four-feet thickness produces a more dense coke than twelve inches. Besides, a twelve-inch thickness of coke is subjected to only one-fourth of the time to the heat of the oven.

Mr. Berkley—It will be drawn within twenty-four hours, whereas a four-feet will require ninety-six hours.

Mr. Ramsay—It depends much on the quality of the coal. We have five feet deep of coal, and we find the coking process complete in less than ninety-six hours.

The President—Is the coke in such cases good in quality?

Mr. Ramsay—It took the prize at the Exhibition in France.

The President—Your experience is, the deeper the coal the denser the coke is?

Mr. Ramsay—Yes, if you give it time.

The President—The upper part of the coke must receive carbon from the bottom part of the coal, by the gases passing through it in the process of coking?

Mr. Ramsay—You make the coke denser by a great depth of coal. You make it produce as much as seventy-six per cent. Water increases the weight, but not, of course, the density. We tried an oven a month ago, and we found the coke fifty-five and fifty-eight per cent.; but when we drew it, well watered, it was seventy-two per cent., though, I believe, the latter was burnt two days longer.

A Member—You get six or seven per cent. more by loading the ovens very heavy, and burning them a longer time—say 160 hours.

The President—All this is consistent with what I conceive to be the fact, that the upper part of the coke in the oven acquires carbon during the process of coking, from the lower part of the coal. It thus becomes more dense; therefore, the deeper the coal put into the oven the better. But I cannot very well understand how pouring in water should have the effect of increasing the density of the coke. It fills the interstices, and so produces additional weight mechanically, but the real density of the coke remains the same.

Mr. Ramsay—All the coal is watered before it is put into the oven.

The PRESIDENT—Does this give you greater produce?

Mr. RAMSAY—Yes, but the coke is not of such good quality.

The PRESIDENT—Do you think the coking is as perfect as that of dry coal?

Mr. RAMSAY—It is more like a piece of metal, bright and glossy.

Mr. BERKLEY—I cannot say it increases the per centage. It is the common practice to put water on the coals. It tends to promote the basaltic form of the coke, the steam passing through it and splitting it into a columnar shape. The gases pass off more rapidly, and the heat is generated quickly. The higher the temperature you can get in the oven the denser the coke.

Mr. REID—By using water you get rid of the deleterious gases?

Mr. STEAVENSON—The hydrogen of the water creates additional heat, and makes the coke denser. The heat of the oven might decompose the steam, and thereby generate a greater amount of heat.

A MEMBER—It should be used where sulphur is predominant. I have not noticed sulphur in the washed coal.

The PRESIDENT—Before you can test the beneficial effects of the use of water and steam, you should try it with the same coal.

Mr. RAMSAY—We did so, and sent the coal to be tried with the locomotives. Many coals make coke by using the galvanic battery, which would be too sulphureous without it. Many years ago, I had a large galvanic battery made. Some inferior coal was coked with the galvanic battery, which could not have been used without it.

The PRESIDENT—How do you explain its action?

Mr. BERKLEY—By the decomposition of the bi-sulphuret of iron. It leaves the iron by itself.

Mr. RAMSAY—Mr. Church has a patent for it. My opinion comes to this—it does improve bad coal, but is not required for good coal; consequently it has not been generally used.

The PRESIDENT—It had a certain effect, no doubt, but not sufficiently great to make it of commercial value.

Mr. RAMSAY—In 1844 the coke trade was not so large as it now is. It would be of no ultimate advantage, because it was bringing inferior coal in for coking, which should not be so used.

Mr. BERKLEY—At page 115, second paragraph, Mr. Steavenson alludes to covering the coals with small refuse coke, in order to save the coke. I quite agree with him in this.

The PRESIDENT—Which acts by excluding the air from the hot coke.

Mr. BERKLEY—Instead of the coke burning away, the *debris* burns

away. I agree with Mr. Steavenson in nearly all he says on this part of the subject. At the bottom of page 116, he says—"The result of experiments which I have made is, that from nine and a half to ten cwts. of water are sufficient to cool a ton of coke." I can corroborate this by actual measurement of water three months by the meter. I use eight and a half to nine and a quarter cwts. As this water is to pay for by the gallon, it becomes important.

The PRESIDENT—Mr. Cox likewise estimates the quantity of water used.

Mr. STEAVENSON—That is in a paper of his, which he read to the South Wales Institute. I give the quantity I use in a note.

The PRESIDENT—You may pour it in, but it does not seem to require such a quantity of water to cool down the coke.

Mr. DUNN—Are you in favour of flues or chimneys?

Mr. BERKLEY—In windy weather, the coke in the ovens without chimneys would be almost all spoiled. As Mr. Steavenson says, the flame would be driven out at the door.

The PRESIDENT—The effect of the chimney is to make a steady draught. Assuming the fact that a tall chimney increases the draught, how does it operate on the coke?

Mr. BERKLEY—When the chimney is tall, the wind has no effect in checking the regular draught of air into the oven. This applies to a high wind only.

The PRESIDENT—Because the draught of air is steady, you think it improves the coke?

Mr. BERKLEY—If you let in too little air or too much air, the quality of the coke is injured. You never let the air go into the mass of coal; it just passes over the top.

The PRESIDENT—How does the wind blowing into the ovens affect the coke?

Mr. BERKLEY—The gases would not get out of the oven freely.

Mr. RAMSAY—Suppose there are no flues and no chimneys. Do not they always regulate the draught on a windy day?

Mr. BERKLEY—On such a day as this the draught, I think, could not be regulated. [The day was exceedingly windy.]

Mr. RAMSAY—I have five ovens in a windy situation. The flame never comes out of the doors. In such cases we close the door, and regulate the exit of the flame out of the top of the oven. There is a greater waste of coke with chimneys than without them. The draught is greater.

Mr. Berkley—You should have a damper in every oven, to regulate the draught of air.

The President—If the tall chimneys are properly regulated by dampers, and in good order, your opinion is that, even in such case, they are not better than ordinary ovens, well regulated in the manner described by you?

Mr. Ramsay—That is my opinion.

Mr. Berkley—You want more air at one time than another, and that is best accomplished by ovens with flues and a chimney. As the heat increases, the gases are generated more rapidly, and you require, when the gases escape, that there should be oxygen to combine with them. In page 118, Mr. Steavenson says—"Many manufacturers prefer loading at the door," &c. I have had no experience of coals tipped in at the top of the ovens.

The President—Your ovens are loaded at the door?

Mr. Ramsay—I think that loading the ovens at the door produces better coke than when loaded at the top. The fire passes down more uniformly. It cannot pass down equably in ovens loaded at the top, because the coal is denser in the centre than on the sides of the oven, and consequently the process of coking is not regular. At Roddymoor and Crook the coal is very dry and light, and, therefore, less dense in the centre of the oven than in some other coal, especially the Busty Bank coal.

The President—We have now, I think, discussed the mode of burning very fully. The time of coking seems to depend upon the thickness of the coal in the oven. What is the effect of letting air in at the bottom of the oven, by flues under the floor of the oven? These are closed when the process of coking is going on, and opened when it is complete.

Mr. Ramsay—As soon as the coking process reaches the bottom of the oven you cool it, to prevent the coke from continuing to burn, and, therefore, wasting. Church passes the air round the oven, as well as underneath the bottom; after this, he lets it out behind.

Mr. Berkley—The patent oven used at Mickley is the patent oven which Mr. Steavenson refers to, plate I., vol. VIII. I think the lower part of the coal coked by the heated air passing under the bottom of the oven, at the same time that the coking process is going on from the top in the usual way, will not be of uniform quality, and there will be a layer of uncoked coal in the centre of the oven.

Mr. COCHRANE—In the experiments at Mickley we found that it was only the silvery lustre that was lost. The coke was really as good in quality. You cannot attain this by the other patent ovens. This is in Breckon and Dixon's specification. They have about fifty ovens at Mickley, with three feet six inches to four feet of coal, and burning forty-eight hours. The front door is closed immediately the floor is charged with coal, and the heated gases pass off through the top of the oven.

The PRESIDENT—The gases must pass through the uncoked coal?

Mr. COCHRANE—Yes.

The PRESIDENT—Is there not a waste of coal between the two layers?

Mr. COCHRANE—The yield is better working forty-eight hours, instead of ninety-six, and they get sixty-seven per cent., instead of fifty-six, which they were getting before. Dunning, at a much prior date (1853), combines almost as much as Breckon and Dixon. In these ovens the great object is to preserve the heat at the bottom. Generally we cool the bottom of the oven.

The PRESIDENT—When you draw the coal out of the patent ovens, does not the bottom cool down?

Mr. COCHRANE—Very little. They say, when the coke is treated in every respect the same as in the best ordinary ovens, there is no depreciation, except in the appearance. The coke is shorter and more friable. It is, however, an expensive oven to construct, and to maintain also.

The PRESIDENT—There is the long oven, which we have not yet discussed.

Mr. STEAVENSON—Yes; I mentioned it as being thirty feet long.

The PRESIDENT—Will you give us a drawing of this oven? Where is it erected?

Mr. STEAVENSON—At Mr. Pease's collieries.

Mr. BERKLEY—I would mention to Mr. Steavenson one thing with regard to the consumption of coke by railways. In a paper, read by Mr. R. Stephenson, to the Institute of Civil Engineers in 1855, it is stated to be 1,300,000 tons, estimating 36 lbs. per mile consumption by locomotive engines. I do not know whether this is all over the world, or applies only to the United Kingdom.

Mr. REID—It is the United Kingdom.

Mr. BERKLEY—Mr. Steavenson has the consumption 641,611 tons.

Mr. REID—He refers solely to Great Britain.

The PRESIDENT—As the subject of coking is very important, shown

by the immense consumption, it appears to me to be very desirable to have plans and descriptions of the different kinds of ovens in actual use, with any observations of a practical nature, from which we might arrive at a correct conclusion as to the results in practice of the various kinds of ovens. I would suggest, as Mr. Steavenson has given the subject great consideration, and as his practice is in a district from which a very large proportion of the coke produced in this district is manufactured, that he be solicited to furnish the Institute with drawings and descriptions of such ovens as he may deem useful, in a practical point of view, and which may enable us to arrive at some definite result by discussion hereafter.

After some desultory conversation amongst the members, Mr. Steavenson undertook to lay before the Institute, at their next meeting, plans of the different kinds of ovens, with a short description of each.

The meeting then adjourned.

NORTH OF ENGLAND INSTITUTE

OF

MINING ENGINEERS.

GENERAL MEETING, THURSDAY, NOVEMBER 1, 1860, IN THE ROOMS OF THE INSTITUTE, WESTGATE STREET, NEWCASTLE-UPON-TYNE.

NICHOLAS WOOD, ESQ., PRESIDENT OF THE INSTITUTE, IN THE CHAIR.

The SECRETARY read the minutes of the Council Meeting, after which the following gentlemen were elected members of the Institute, viz.:—Mr. John Peele, Springwell Colliery, Gateshead; Mr. Thomas Dakers, Brancepeth Colliery, Durham; Mr. John Cooke, Willington Colliery, Durham; and Mr. Albert Verner.

The PRESIDENT said, with regard to Mr. Stephenson's legacy of £2000, he had written to the solicitor of the executors to inquire if any special instructions by the donor had been given in the will as to its appropriation, or if it was for the general purposes of the Institute.

A resolution was adopted in accordance with a recommendation of the Council, that the monthly meeting in December be made a special meeting for the election of officers in cases of vacancy.

The PRESIDENT then begged to mention the particulars of a discussion which they had just had in the Council of the Institute, as to whether it might not be advisable, instead of holding all their meetings in Newcastle, to hold some of them in some central part of some of the other coal districts of the kingdom. They had a great many members residing in distant parts of the country, and it might be well to hold a meeting occasionally in the Midland, or other coal districts of the country, so that such members might have an opportunity of being present at the discussions; and he had no doubt it might be arranged that important matters should be discussed at such meetings. It appeared to the

Council that such a meeting might be productive of great benefit to the members of the Society generally, and to the young members particularly, by bringing them more immediately into connexion with the members of other districts; and it would give them an opportunity, likewise, of seeing what was going on in these districts; and thus, whilst they would be extending their information, it might also be a means of getting together, on these occasions, a much larger number of the members of the Institute than generally takes place at their ordinary meetings at Newcastle. It would be desirable that such a meeting, if deemed advisable, should be held in some one of the summer months, and, therefore, there would be sufficient time to consider the proposition. He mentioned the subject now, that it might be considered at a future meeting.

Mr. Spencer's paper on Pillar Working having come on for discussion, the PRESIDENT said, the paper treated of the mode of Working Pillars at small depths from the surface, but, as he had previously remarked, they should not stop there. They had not yet discussed the question as to the best mode of working pillars generally. The discussion should embrace the working of coal at all the different depths, from say ten fathoms to three hundred fathoms, that being, he believed, the range of working coal in the counties of Northumberland and Durham. The late Mr. Wales approached the subject, to a certain extent, in his valuable papers on ventilation; but these papers being specially devoted to ventilation, did not, except incidentally, enter upon the question of working coal, or of obtaining the greatest quantity of coal, in the best condition, and at the least possible cost, which were the elements of discussion of the paper before them.

Mr. CRONE said, he had put upon paper some remarks as to the method of pillar working at Dipton Colliery, under similar circumstances to those enumerated by Mr. Spencer in his paper, where, in consequence of the roof of the coal being so friable and tender, it was found difficult to remove the pillars at all. He had extended these observations to some remarks on the working of pillars generally, in the early days of coal working, and he had continued these observations into the period immediately preceding the introduction of safety-lamps, and into the period when these lamps were introduced, making some observations on these lamps, and ending with some remarks on the mode of working a thin bed of very hard coal at Seaton Burn; and with the permission of the meeting he would read these observations.

OBSERVATIONS

ON

PILLAR WORKING

IN THE

NORTHUMBERLAND AND DURHAM COLLIERIES.

By Mr. STEPHEN C. CRONE.

The paper on some methods of Pillar Working, communicated to the Institute by Mr. Wm. Spencer, Jun., having given rise to the anticipation that the subject would be continued by other members, I herewith offer some instances of pillar working which, I trust, may be deemed of a sufficiently interesting nature to warrant my laying the same before the Institute.

The requirements of pillar working having been clearly explained to the Institute in the paper above referred to, it is scarcely necessary to state that great care and attention is imperatively required to protect the workmen from accidents during the process of removal, as there is generally a certain amount of danger. This, however, is greatly lessened if proper precautions are taken and a system adopted suitable to the exigences of the case, almost every colliery offering varying features from others, requiring modifications of the plan usually followed, which ought to be arranged so as to obtain the largest per centage of coal of the greatest commercial value, and with as little loss of timber and other material used as possible. To illustrate the subject more fully, I have ventured to add some examples of old colliery workings, and the reducing or partial removal of pillars, which may not be generally known. These are of comparatively little value in the present day, further than to show the great loss of coal sustained by the old system of working contrasted with more modern methods.

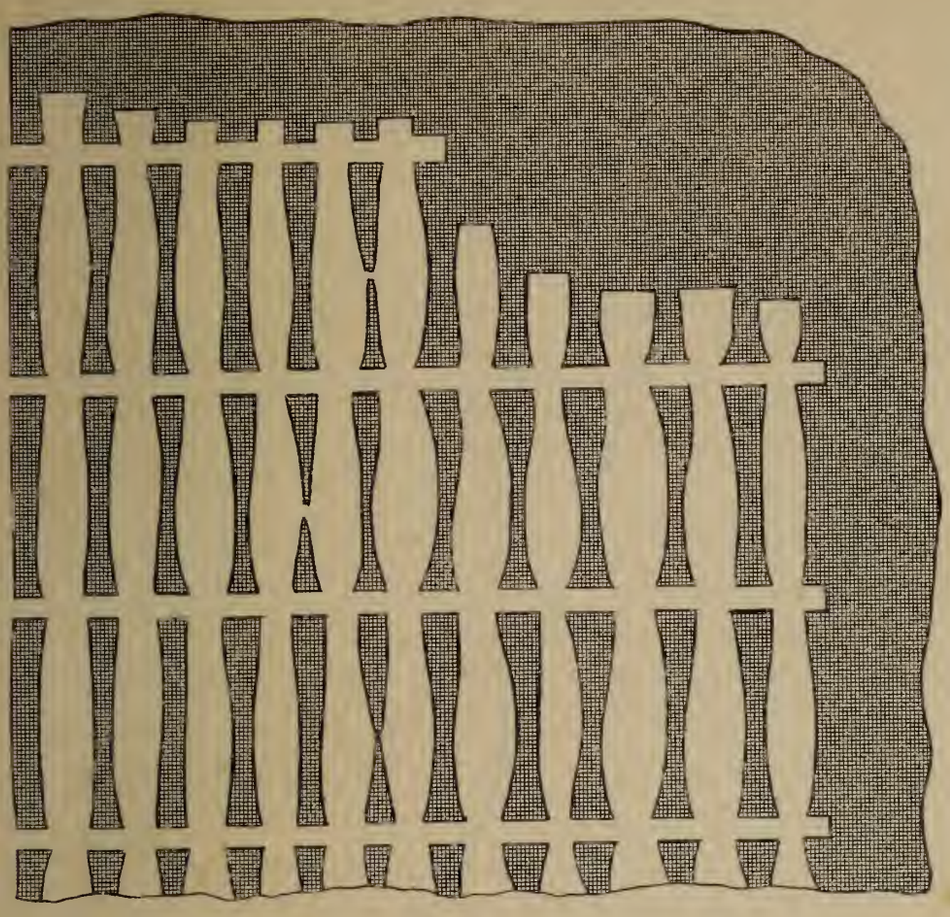
Referring to plate I. No. 1 are some old workings near the outcrop of the Hutton Seam at Dipton Colliery, apparently of very early date. It is evident such a plan could only be followed to a very limited extent, and under very favourable circumstances, with a cover of from ten to twenty fathoms. The pillars are fifteen yards long, walls two yards wide, from which the bords are turned away three yards wide, being gradually widened out in the middle of the pillar, leaving the latter extremely thin, the bords frequently holed into the next adjoining. The bords were again brought into a width of three yards before holing into the headways course, with a view, no doubt, of keeping the latter open and upstanding. The coal left and lost in the pillars would, probably, be about from twenty to thirty per cent.

No. 2, plate I., is also a plan of thin pillar working at the same colliery, the pillars are twenty-four yards long and from two to three yards wide, the bords four yards and the walls two yards; these being the only effective excavations, the pillar being abandoned, causing a loss of thirty-three per cent. of coal, as well as endangering the entrance of the mine, unless the seam of coal, the stratum immediately above and below it, are of a very hard nature, and sufficiently thick to resist the pressure of the incumbent strata. No great extent of workings could be excavated on such a system. Should the bottom be of such a firm texture as to resist the pressure and the coal less so, these thin pillars would be crushed to dust by the settling down of the strata above occasioning what is called a "thrust." An incident seldom heard of in the present day in collieries of any extent. On the other hand, should the roof of the mine and the coal be of moderate hardness and strength, and the bottom less so, the pillars of coal would be forced downward, compressing the stratum beneath it to such an extent as to cause it to rise upward into all the excavations of bords and walls formed. This is technically called a "creep," a section of which is shown in plate No. IV.

When a "creep" takes place with such thin pillars as No. 2 being left, it would be almost impossible, and, certainly, not advisable, to keep the working face open, as, under any circumstances, even with large pillars, it is an expensive process to contend with creeping places, the only means at command, until roof and bottom meet, being to cut out the bottom as it is forced up. Whilst referring to the creep, it may be necessary to add, there is generally a slight movement in all the broken workings, unless the seam is very shallow. The roof and bottom being firm, and the seam of coal either worked entirely out, or such

Old Plans of Coal Workings with Thin Pillars

Nº 1.



Scale 20 Yards to an inch

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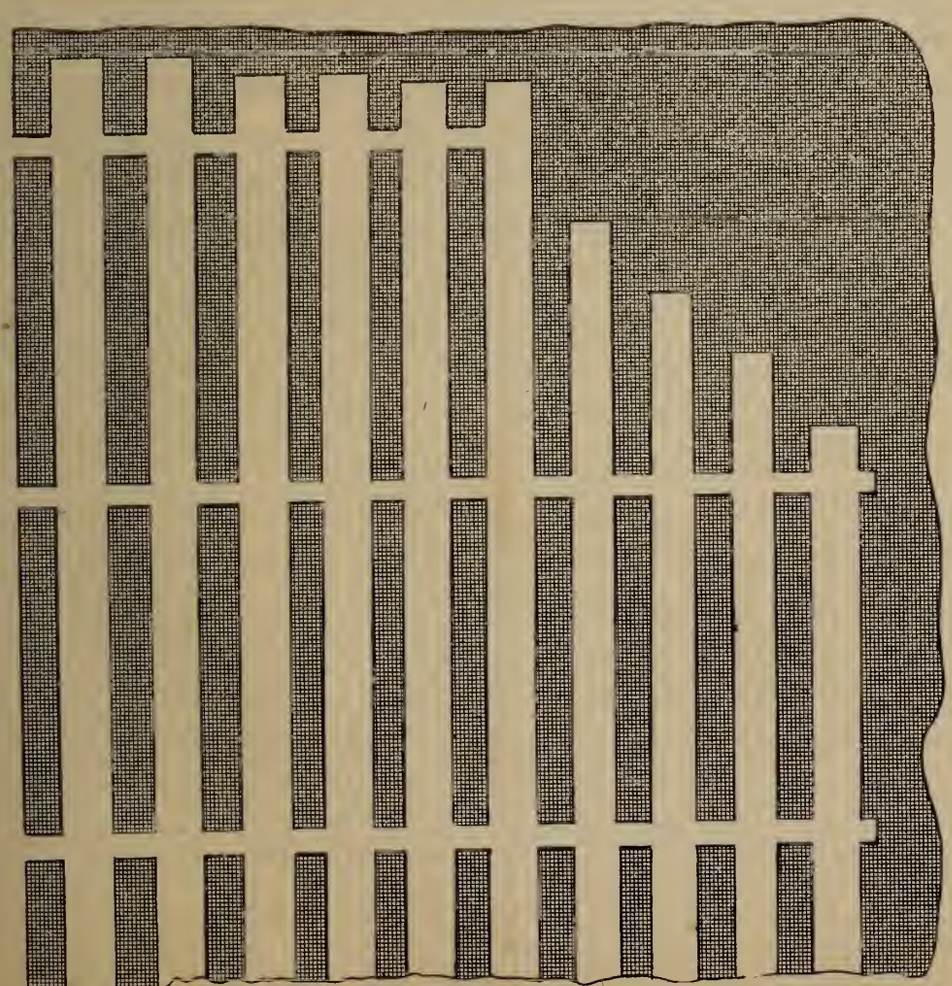

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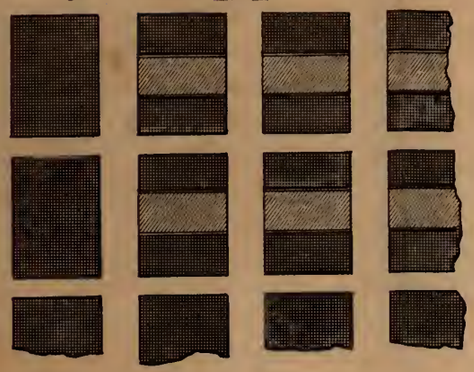
Lithographed by A. Reid Newcastle

Old Plans of reducing the Pillars, or partial Pillar Working, High Main Seam, Killingworth Colliery.

N°1



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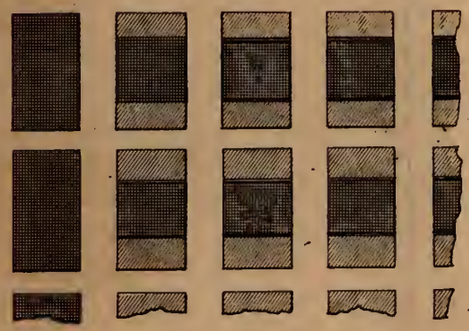

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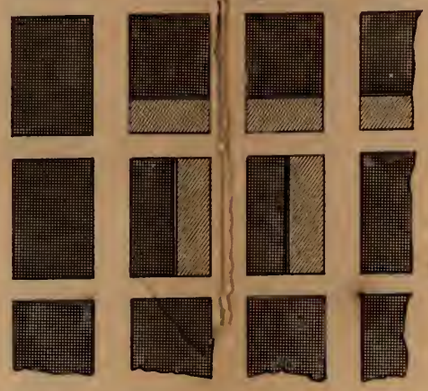

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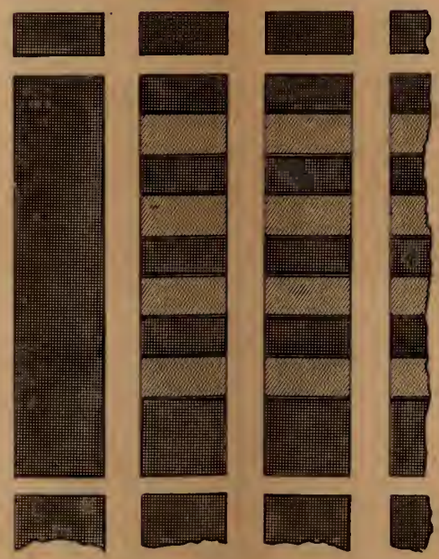

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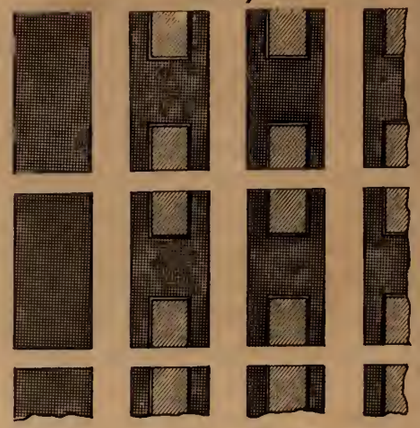


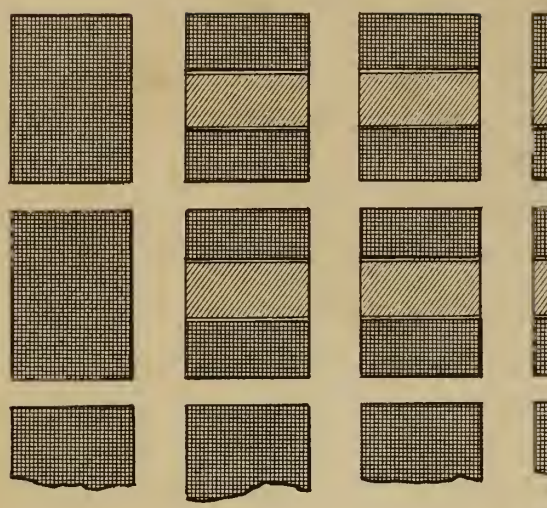
N°8

Scale 20 yards to an Inch.

(Proceedings N° of E.I of M.E. 1860-1.

Lithographed by A.Reid, Newcastle

N°1.



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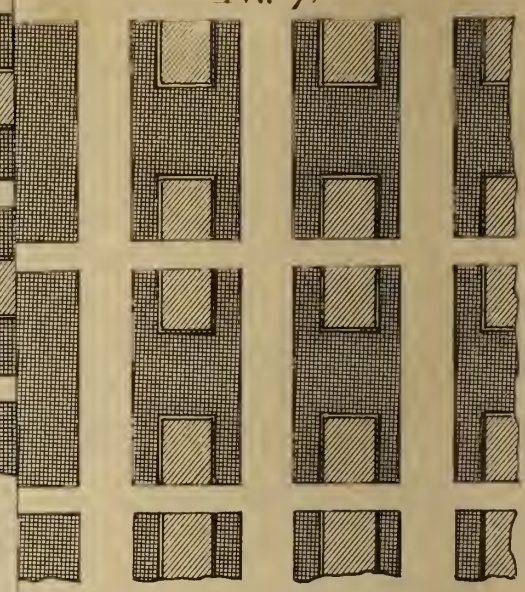

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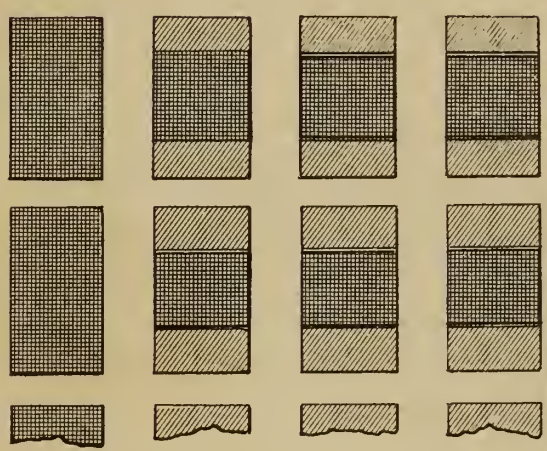

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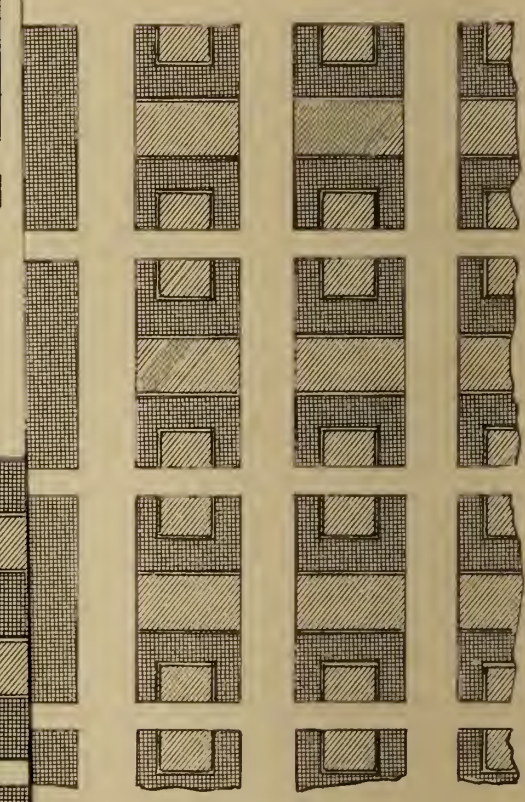

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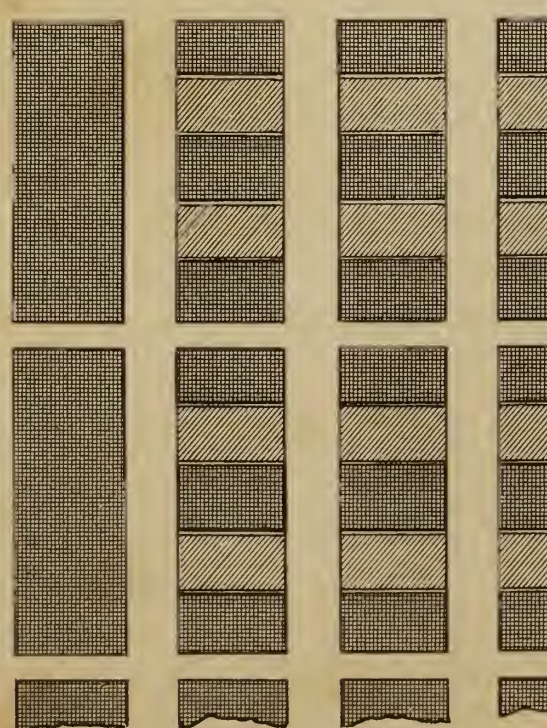


Scale 20 yards to an Inch.

Lithographed by A. Reid, Newcastle

small portion only left as will be readily crushed down by the weight of the strata above, a partial creep takes place. It is always, therefore, most desirable to remove all the coal, if possible, so as to allow the roof to fall freely. When large pieces of coal are left, it often happens the roof is supported and hangs upon such coal, frequently causing creeps of a very troublesome nature. A creep almost invariably occurs, as previously remarked, where the roof is strong, the coal seam of a yielding nature, and the bottom soft, but to a less or great extent, produced in working, according to the facilities of removing the whole of the coal, and as the pillars may be large or small. Whilst removing large pillars the creep is only felt in the vicinity of the juds, and not even there, to any serious extent, if good falls can be procured in the goaves. With small pillars, under the same circumstances, the creep is general throughout all the various openings, often entirely closing the bords and walls of the first working, as in plate IV.

In old workings we also find larger pillars left 6, 8, or 10 yards, a portion of which has been removed by driving a jenkin through and scooping out the middle of the pillar, similar to No. 1, plate I.

In collieries of greater depth pillars have been partially removed, examples of which are given in plate II., taken from the old workings of Benton and Killingworth Collieries. These operations require a little explanation. The left hand pillars are shaded dark, to show their original size, the part taken out shaded light; bords and walls not shaded. The following is the No. of each plot in the plate, size of pillar in yards, and per centage of the whole coal lost:—

No.	1	pillar,	12	yards	×	9	yards,	40	per cent.	of coal lost.
„	2	„	12	„	×	7	„	28	„	„
„	3	„	22	„	×	8	„	39	„	„
„	4	„	12	„	×	8	„	31	„	„
„	5	„	40	„	×	9	„	40	„	„
„	6	„	12	„	×	8	„	41	„	„
„	7	„	16	„	×	8	„	41	„	„
„	8	„	15	„	×	8	„	32	„	„

Our President, from his extensive and varied experience of these practical details, will doubtless be enabled to give some information of these partially wrought pillars. It is not without a slight feeling of regret at the great loss of coal sustained by this system of working, yet, we must be just as well as charitable towards our predecessors, when we consider their position at the time, and the great advantages we now

possess over them, in having the safety-lamp to guard us against the insidious attacks of our enemy, the light carburretted hydrogen gas of our mines. They had nothing but the naked light, or the expensive and uncertain scintillations of the steel mills, or, as our old pitmen have reported, the dim spectral phosphorescent light of fish heads or skins, to protect them from danger. In a seam such as the High Main of the Tyne, giving off large quantities of this gas, it was quite impossible to remove the whole of the pillar and form a goaf to become a large reservoir of gas, with such inadequate means at their disposal to light the mine. Under these circumstances they removed as much of the pillar as they could do with safety, and to retain the ventilation. These designs may seem fanciful in the present day, yet, in the past, we must admit they were very ingenious.

I shall now refer to the more immediate subject of this paper,—the removal of pillars,—which have come under my notice and direction; avoiding those systems as far as possible which have already been published in the "Transactions" of the Institute. The following reference applies to the plates III., IV., V., VI., VII., and VIII.

That part shaded dark represents ..... coal.
That part coloured blue represents ..... goaf.
That part shaded lightly represents..... lifts, jenkins, and places advancing in the pillar to facilitate removal.

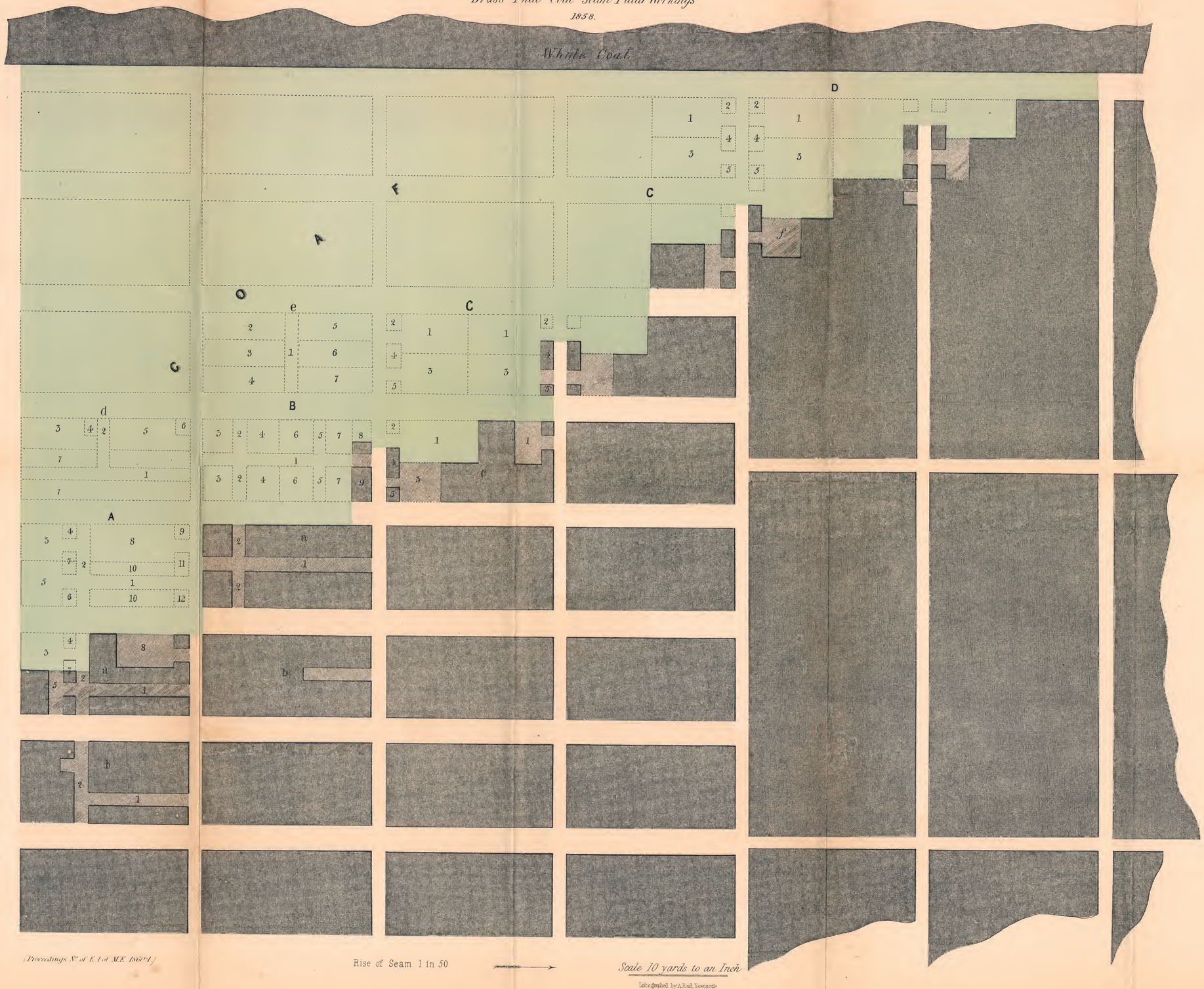
The dotted lines show the outlines of the pillars, and the various operations in removing them. The Nos. refer to each portion of the pillar consecutively, as taken off, for instance, 1 is the first operation, 2 the second, &c., to the highest number, which is the last operation. This method of numbering will render the plans sufficiently plain to practical members without much explanation. The rise of seam is given and the direction shown by the arrows.

Plate III.—The pillars in the Brass Thill Seam, Dipton Colliery, were found extremely difficult to remove, although only at a depth of thirty-five fathoms. (See section of strata.) The cause of this was principally owing to the roof being composed of a loose, friable black shale, and the Five-Quarter Seam being worked above. The space between the two seams varied, but was generally about eleven feet. The thickness of the Brass Thill Seam, five feet six inches, of a medium texture and hardness; large patches were very much crushed and rent with open fissures, caused either by the creep in the Five-Quarter Seam above, or by the Hutton Seam being all, or nearly all, worked away,

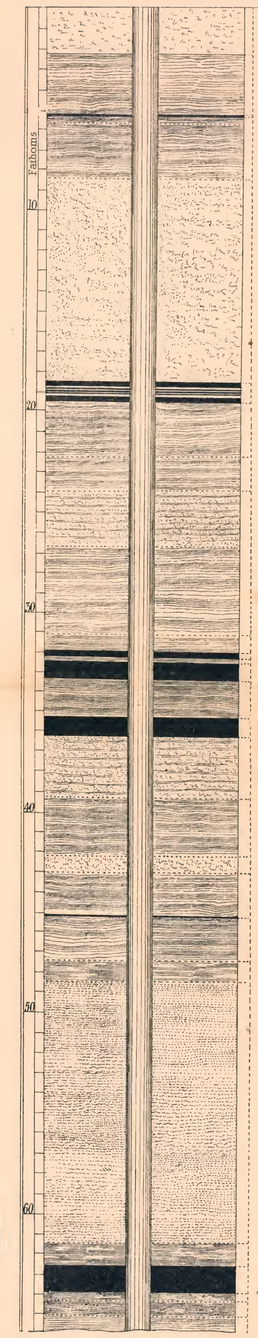
DIPTON COLLIERY

Brass Thill Coal Seam Pillar Workings

1858.



Section of Strata at the Shaft.



	Faths	Ft	Ins
Clay	2	1	4
Blue Metal with Ironstone Girdles	3	0	0
Coal	0	0	9
Slate Fire Clay	0	1	9
Blue Metal	2	4	6
Post Freestone	10	0	2
Shieldrow Seam	1	0	11
Blue Metal with Ironstone Girdles	2	4	6
Blue Metal	1	3	8
White Post with Metal Partings	2	4	7
Blue Metal with Ironstone Girdles	5	0	1
Five Quarter Seam — Coal		Ft. 1	Ins. 9
Band		1	6
Coal	1	2	9
Dark Grey Metal	1	5	0
Brass Thill Seam	0	5	6
White Post with Metal Partings	3	0	0
Blue Metal with Post Girdles	2	5	8
White Post	0	4	8
Blue Metal with Post Girdles	2	0	10
Coal	0	0	10
Blue Metal with Ironstone Girdles	2	1	0
Grey Metal	1	0	3
Strong White Post	12	5	9
Grey Metal	1	0	0
Hutton Seam Coal and Bands crushed together	1	2	9
Depth to Hutton Seam Faths	63	3	0

(Proceedings N° of E. I. of M.E. 1860-1)

Rise of Seam 1 in 50

Scale 10 yards to an Inch

Lithographed by A.Reid, Newcastle

about twenty-eight fathoms below, or probably a combination of both influences. The Hutton Seam, reported to be eight feet nine inches thick, and composed of coal and bands, would necessarily cause heavy falls when worked away. The roof of the Brass Thill Seam being so short and friable, frequently fell down between the spaces unoccupied by timber, and the face of the working, although the props were not more than from twelve to eighteen inches apart, and about two feet from the face. Much inconvenience was also felt from the large amount of carbonic acid gas which came down from the Five-Quarter workings or goaves immediately above. The headways courses were timbered with baulks about five inches by six inches square, and five feet long, often placed close together. These had frequently to be renewed, and were almost inadequate to keep the roads into the broken or pillar working open. The wide bords generally ran close as soon as the timber was removed. Such was the position in the first pillars formed, in laying out the workings, which were thirty yards by twelve yards. In removing these pillars I adopted several of the usual methods, which were found unsuitable for the peculiar position of the seam. It may be interesting to enumerate some of them. The first method adopted (see pillar A, plate II.) was to drive down a narrow jenkin 1, two yards wide from the outer side of the pillar, rather more than half-way down, after holing wall 2; then driving lift 3 down, leaving stooks 4 and 7. Stook 4 was then removed, and the whole drawn out and allowed to fall. Lift 8 was now turned away (see pillar *a*), and advanced at the same time that 5 was driving down, stooks being left at the end of the lifts to protect the road out; such stooks, or as much of them as could be obtained, being worked as numbered. The coal 10, 10, on each side of the jenkin, was then brought back. Pillar *b* shows the jenkin 1, wall 2, prepared for driving lifts down, as soon as 3 and 5, the lower part of pillar *a*, is off. This plan was not successful. Thin shells of coal were left at the sides of the lifts, but before the lifts could be holed the roof frequently broke down, crushing both coal and timber, and effectually shutting up the coal that had not been removed. The loss of coal by this mode would average about 25 per cent. Pillar *d* was taken off in a somewhat similar manner, by driving jenkin 1, wall 2, then taking a five-yard lift three down, succeeded by lift 5 from the top end. Stocks 4 and 6 were then removed, the jenkin 1 continued to the end, and the coal, 7, 7, on each side brought back up the jenkin, for the whole length of the pillar. Pillar *e* was removed by going down by the

side of the bord, holing the half pillar wall 1, then taking four-yard lifts 2, 3, 4. The other half was obtained by lifts 5, 6, 7, from the headways course. Neither of these latter methods were satisfactory, the per centage of coal lost being much the same as pillar A. In pillar B, jenkin 1 was driven down the middle, with the object of leaving a large amount of coal on each side, to resist the pressure of the roof, the lifts being shortened, and taken off quickly, to reduce the size of goaf supported, and to preserve the timber, by keeping it exposed as short a time as possible. This was effected by holing wall 2, out of which was driven the short lift 3, 3. The timber was then drawn out, keeping in only as much as preserved the face of lift 4, 4, which was taken up to lift 6, 6. The whole was then drawn out, and allowed to fall. In the meantime, walls 5, 5, were holed, and lifts 6, 6, taken off to goaf, and drawn out in a similar manner as 3, 3. Lifts 7, 7, were then taken up to stooks 8, 9, and drawn out. The stooks were then removed. Pillars *a* and *b* show narrow work progressing. This plan was effective, to a certain extent, and an improved per centage of coal obtained; but wishing to obviate the expense of narrow work, and finding that driving these places weakened the pillars too much, and as the results seemed to produce that which we were struggling to avoid, the roof being rather stronger, we adopted the plan as shown in pillar C. The lifts 1 were turned away narrow, and widened out to about six yards, half the width of the pillar. Good stooks, 2, 4, being thus left on each side, about three yards square, the lifts were taken off to half the length of the pillar, and drawn out, a shell of coal, from three to six inches thick, being left next the goaf or old bord to keep out the falling stone. Stook 2 was then removed, and lift 3 turned away and taken off in the same manner as 1. Stooks 4 and 5 were then successively removed, half the pillar going to each headways course. Pillar *c* shows lifts 1 and 3, in course of removal. This method was found very successful, the loss of coal being about 4 per cent. of the whole area, or 6 per cent. of the pillar. It was found almost impossible to keep the headways course open, in the ordinary way, by timber. Headways were driven under the top of the seam, leaving about ten inches of coal for a roof formed into an arch. These resisted the pressure most effectually, and the consumption of pit timber was reduced about two-thirds. This saving was partially effected by ceasing to drive bords, which was a source of trouble and expense. Large pillars were formed, sixty yards by thirty yards, as shown at D. These were most successfully worked away in the broken. The reason

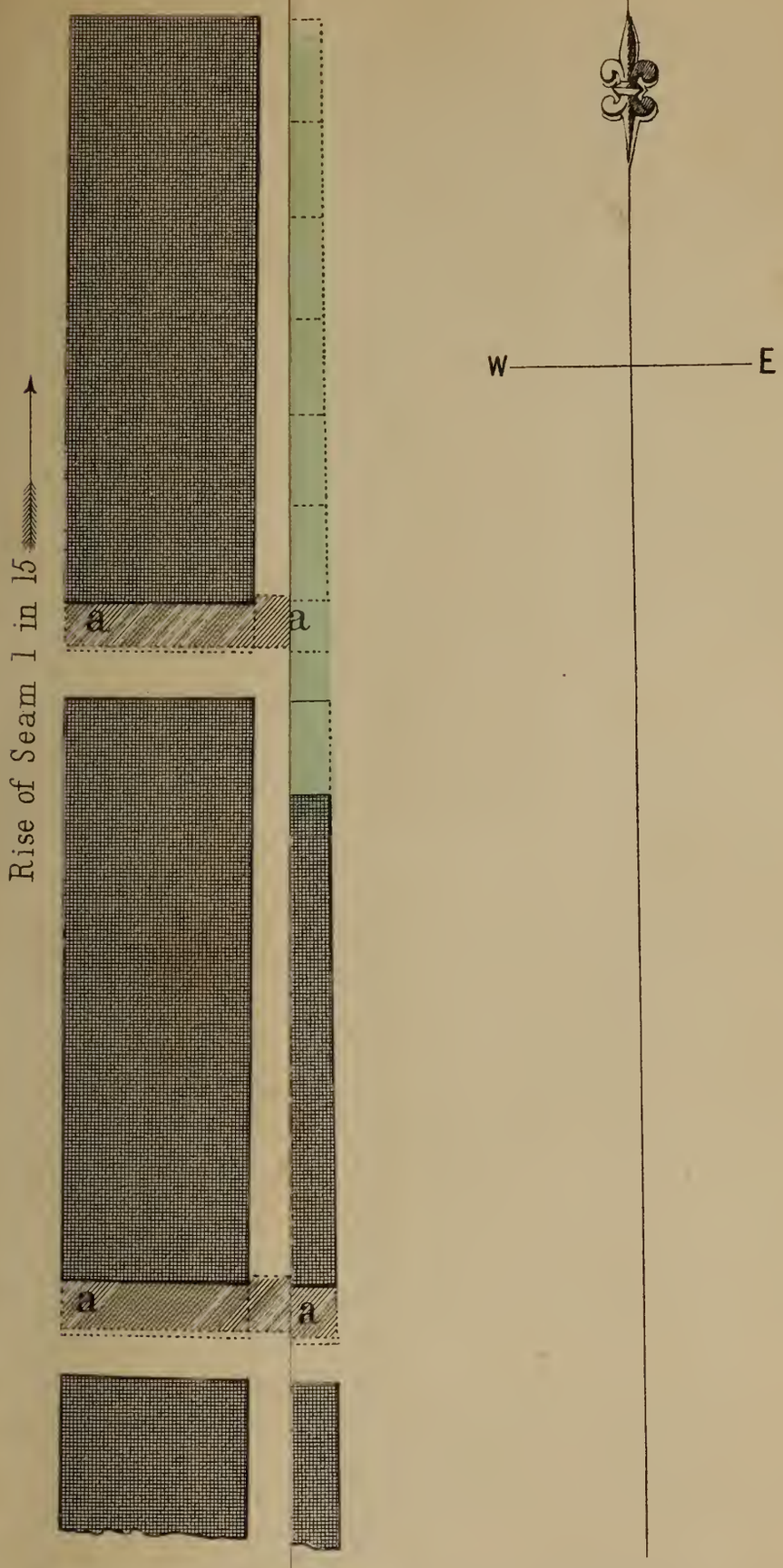
of this is obvious, when thoroughly investigated. Under ordinary circumstances, the pillars left might be considered of ample strength; but when the bad roof is taken into account, the timber having to be drawn out of the bords as soon as possible, to prevent breakage and loss, and the heavy falls which took place in consequence, on each side of the pillar, it is evident that these falls would extend upwards to the Five-Quarter Seam; and from the fact of that seam being partially wrought in the pillars (the workings being found very much crept, and portions of coal left), this would also disturb and injure the stone between the seams, and the nature of the overlying strata, which would be rent, broken, and fallen. It is probable the Brass Thill falls would pass through, and disjoint the strata considerably above the Five-Quarter Seam. This would necessarily cause the strata immediately above every individual pillar to rest upon and crush a portion of it down, as soon as weakened by the process of removal. Hence the difficulty of keeping open the headways courses, from the loose dead weight resting upon them, and the great loss of coal sustained by the first attempts to remove the pillars. The pillars C, C, were probably more effectively removed, from the strata above being less injured, and the protection afforded by the large pillars D, which were worked off in a similar manner to C, taking half the width—fifteen yards of the pillar to each headways course, by driving six yards lifts 1, and 3, on each side protecting the road out of the lifts by stooks 2, 4, 5, which were also removed. *f* is a lift in course of removal. A thin shell of coal was left at the side next the goaf, and again where the west side lift holed, with this exception, all the coal was obtained, the estimated loss being about 3 per cent. of the whole area. This was found to be the best method of removing the whole of the coal, as well as the cheapest, as the largest portion of it was worked at the lowest prices paid for hewing. By leaving these large pillars we gained the following advantages:—The strata above was not disturbed or disjointed, being kept steady by the large extent and firmness of the pillar; the headways courses were protected, nothing like thrust or creep being observed; the lifts of coal in the broken were removed, safely and quickly, as small an extent of goaf as possible, kept supported by the timber, which, on being drawn, the roof broke short off, and relieved that portion resting on the pillar, thus likewise causing it to be the more easily obtained.

The foregoing refers generally to mining at shallow depths, and

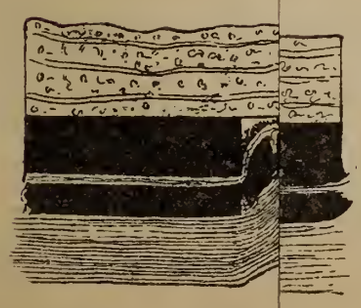
comparatively level. I shall now give some details of pillar working under very different circumstances, at a great depth, and very heavy dip of seam. The High Main Coal Seam at Killingworth Colliery is found at the shaft, 113 fathoms from the surface; but, probably from its being in the vicinity of the Great Ninety-Fathom Dip Dyke on the north side of the Tyne, there is an unusual heavy dip southward, and a consequent rise northward, from the shaft, thus varying the thickness of superincumbent strata to a great extent. The seam of workable coal varies from six to eight feet (see section, plate IV.), generally overlaid with a strong white post roof, eight and a half to twelve fathoms thick, but not uniformly so, as in the east division, plate VII., a stratum of dark grey metal stone, of variable thickness, from a few inches to several feet, intervenes between the coal and the post; there is, however, usually an average good roof. The quality of the coal is good, and strong in its character; but from the great thickness of incumbent strata, height of seam, and softness of bottom, as the large pillars are reduced the coal is often very much crushed, yielding a large per centage of small. The process of removing the pillars is one requiring an active supervision and watchful care of the ventilation, &c., the seam giving off large quantities of light carburetted hydrogen gas, which, from the heavy rise of the seam, would constantly float about the workmen, unless removed by active ventilation.

I will briefly enumerate the methods adopted, the examination of the plans will render this sufficiently plain, observing the old pillars are small, and the new, or modern ones, large in size.

Plate IV. North-west Division; Seam, six feet thick; depth about 180 fathoms; old pillars twenty-six yards long by seven yards in width; bords are headways way, wide bords and walls are crept close. Walls *a a*, about four feet wide, were driven by the side of old headways course, from which jenkins *b*, *b*, *b*, *b*, and 1, two yards wide, were driven to the rise end of the pillar, the remaining portion of the pillar being taken off by siding over four yards lifts eastward to goaf. The whole of the coal was got, the pillars having been left so small had evidently brought on a heavy creep, as shown in the section of crept bords, the bottom of the bords had been forced upward and compressed against the roof, thus causing the pressure of the strata to be balanced. These pillars had been standing about forty years. Before being opened out this year, of course, all movement in the strata had perfectly subsided, several



Section of High Main Coal Seam.



	Ft.	Ins.
Post with Metal Partings	52	6
High Main Coal Seam	6	0
Grey Metal	1	6
Crow Coal (not worked)	2	0
Grey Metal Stone	8	5

Scale 10 Yards to an Inch.

(Proceedings No. of E. I. of M.E. 1860-1.)

KILLINGWORTH

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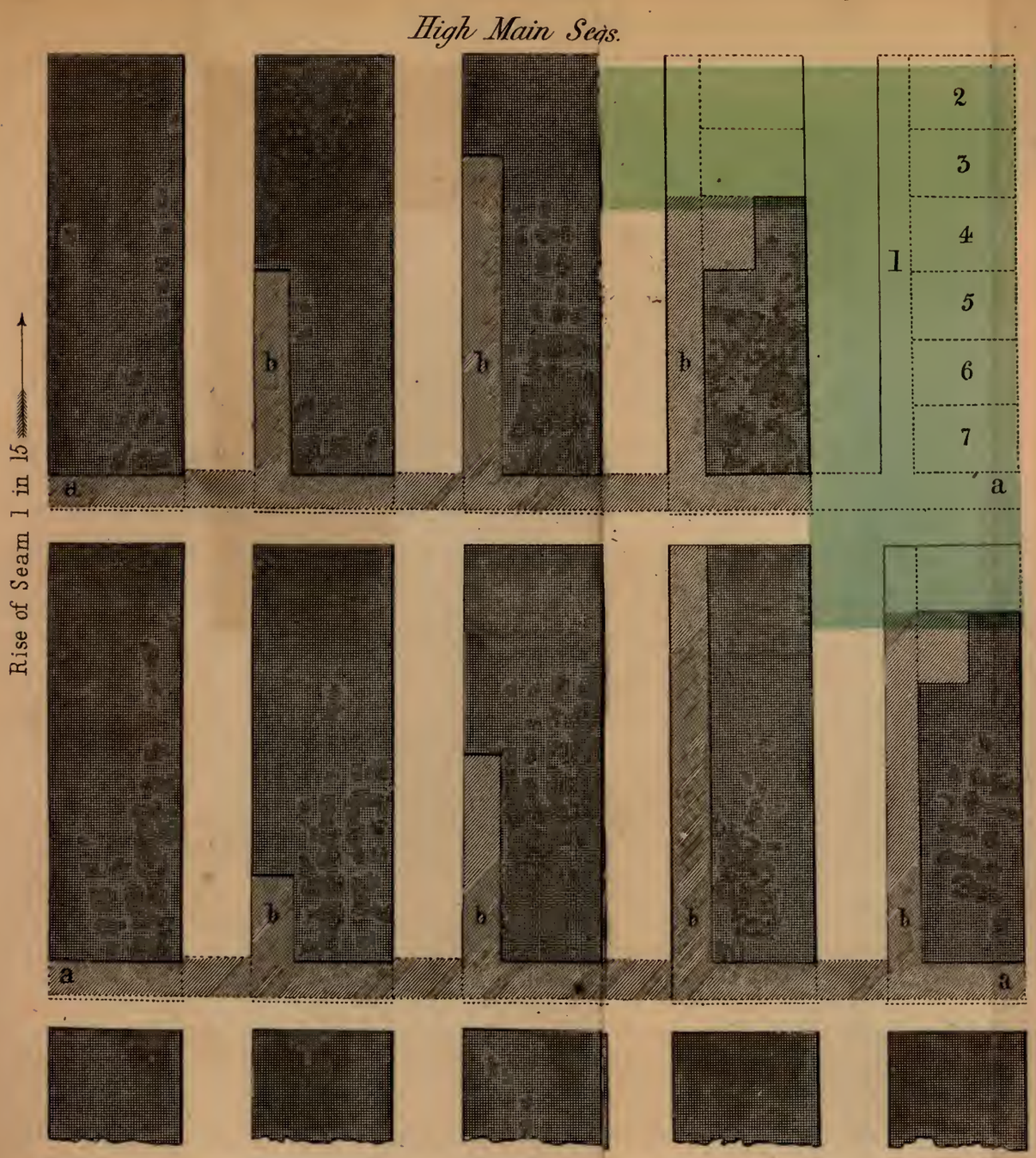
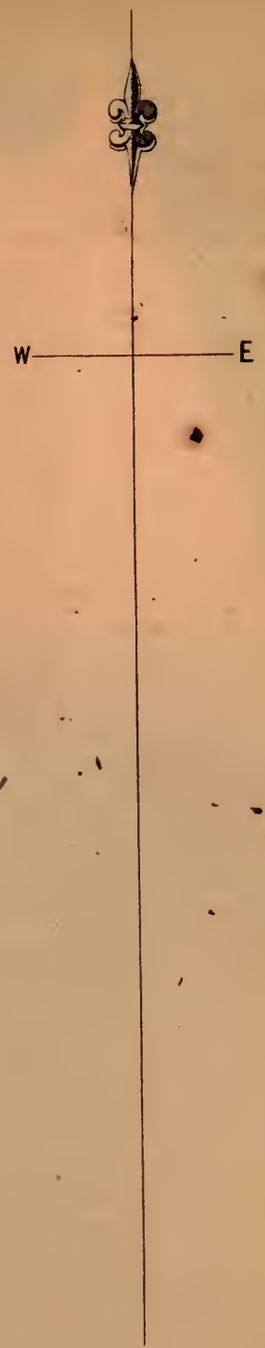
High Main Seams.





Section c

Section of High Main Coal Seam.

	Ft.	Ins.
Post with Metal Partings	52	6
High Main Coal Seam	6	0
Grey Metal	1	6
Crow Coal (not worked)	2	0
Grey Metal Stone	8	5

Scale 10 Yards to an Inch.

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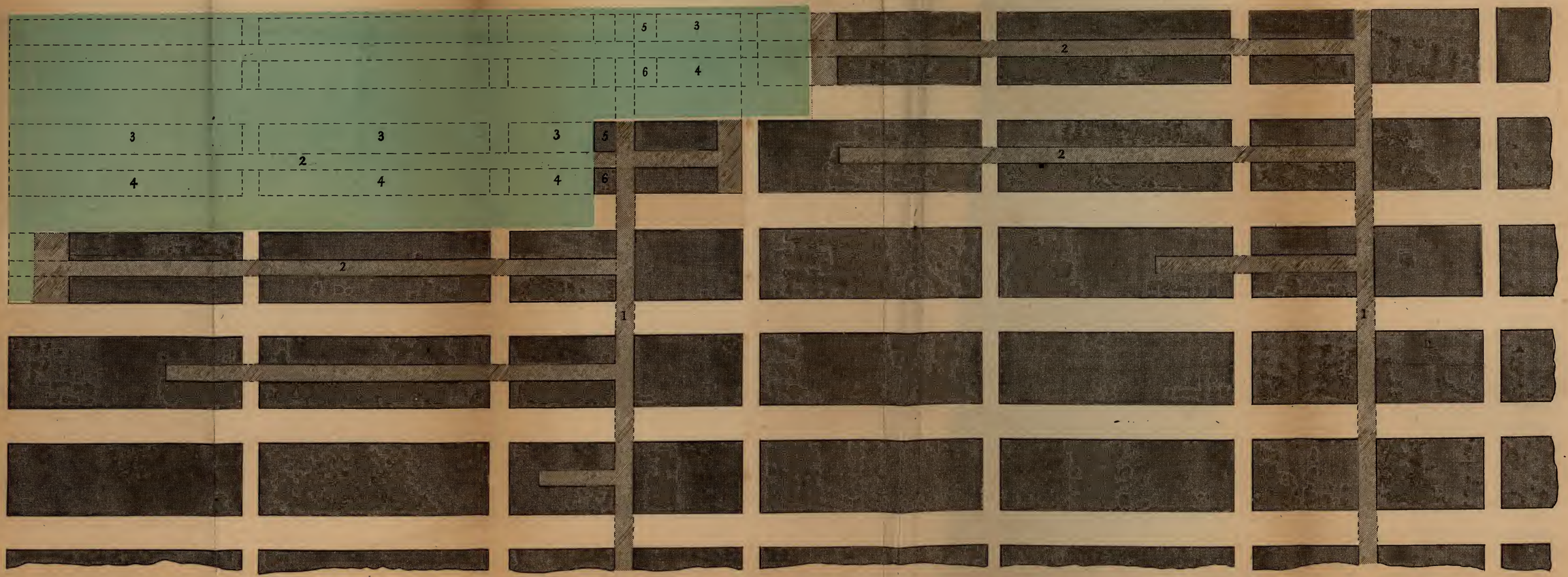
KILLINGWORTH COLLIERY

North East Division.

High Main Seam Pillar Workings.



Rise of Seam 1 in 9.

(Proceedings N° of E.I of M.E. 1860-1.)

Scale 10 yards to an Inch.

Lithographed by A.Reid, Newcastle.

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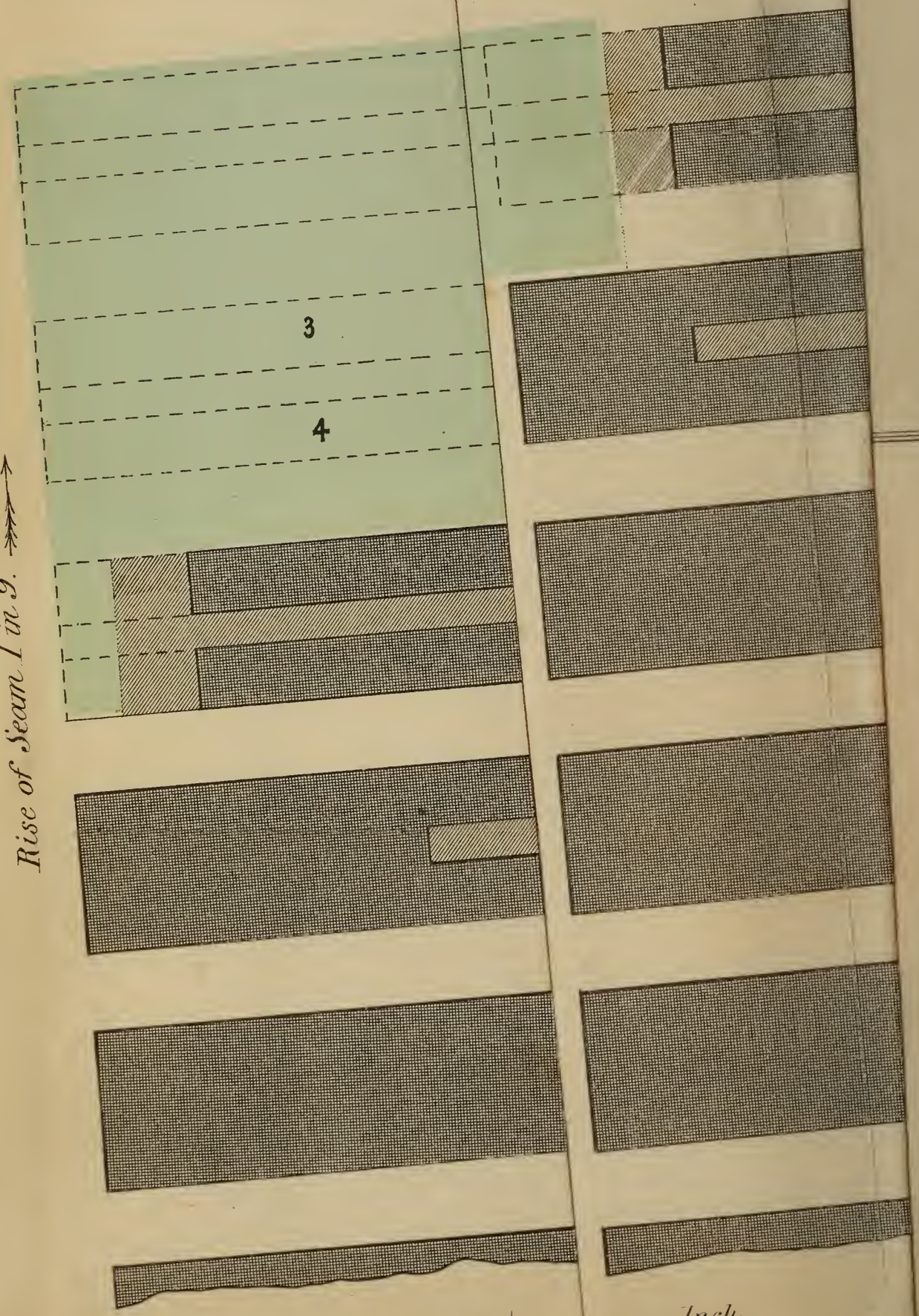

Rise of Seam 1 in 9.

(Proceedings N° of E.I of M.E. 1860-1.)

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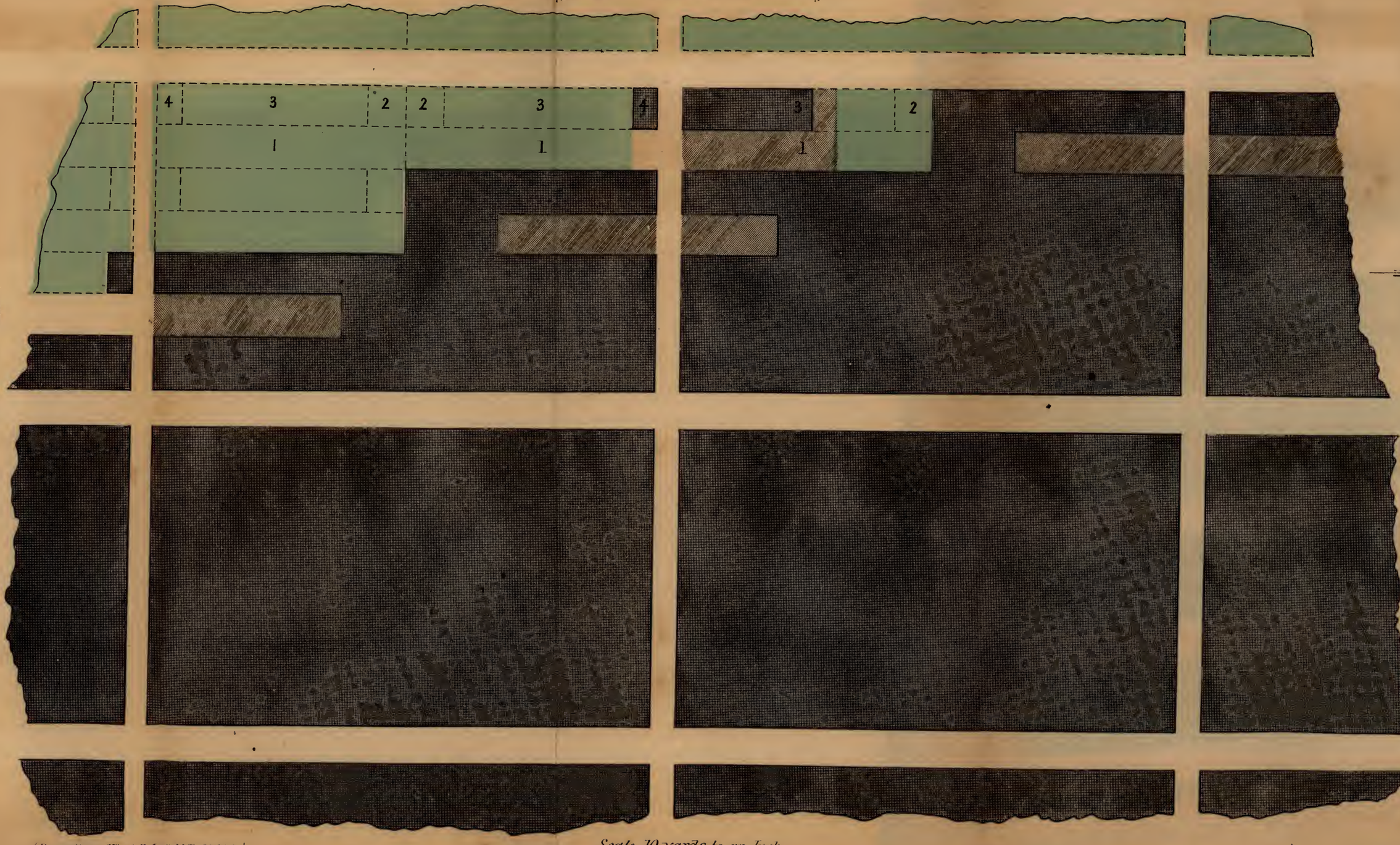
KILLINGWORTH COLLIERY

North West Division.

High Main Seam Pillar Workings.

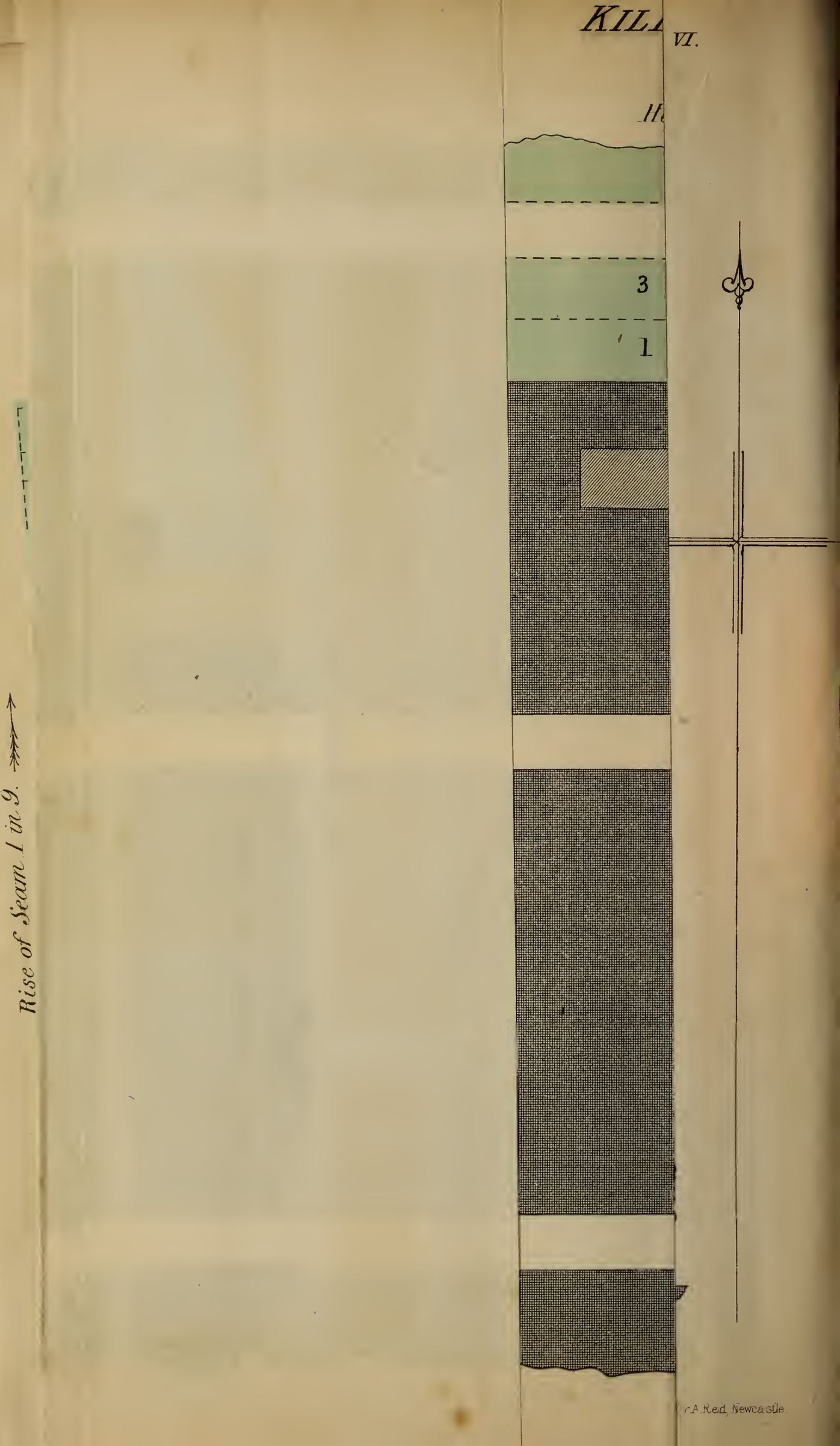


Rise of Seam 1 in 9.

(Proceedings N° of E.I of M.E. 1860 I.)

Scale 10 yards to an Inch

Lithographed by A.Reid, Newcastle.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Rise of Seam 1 in 9.
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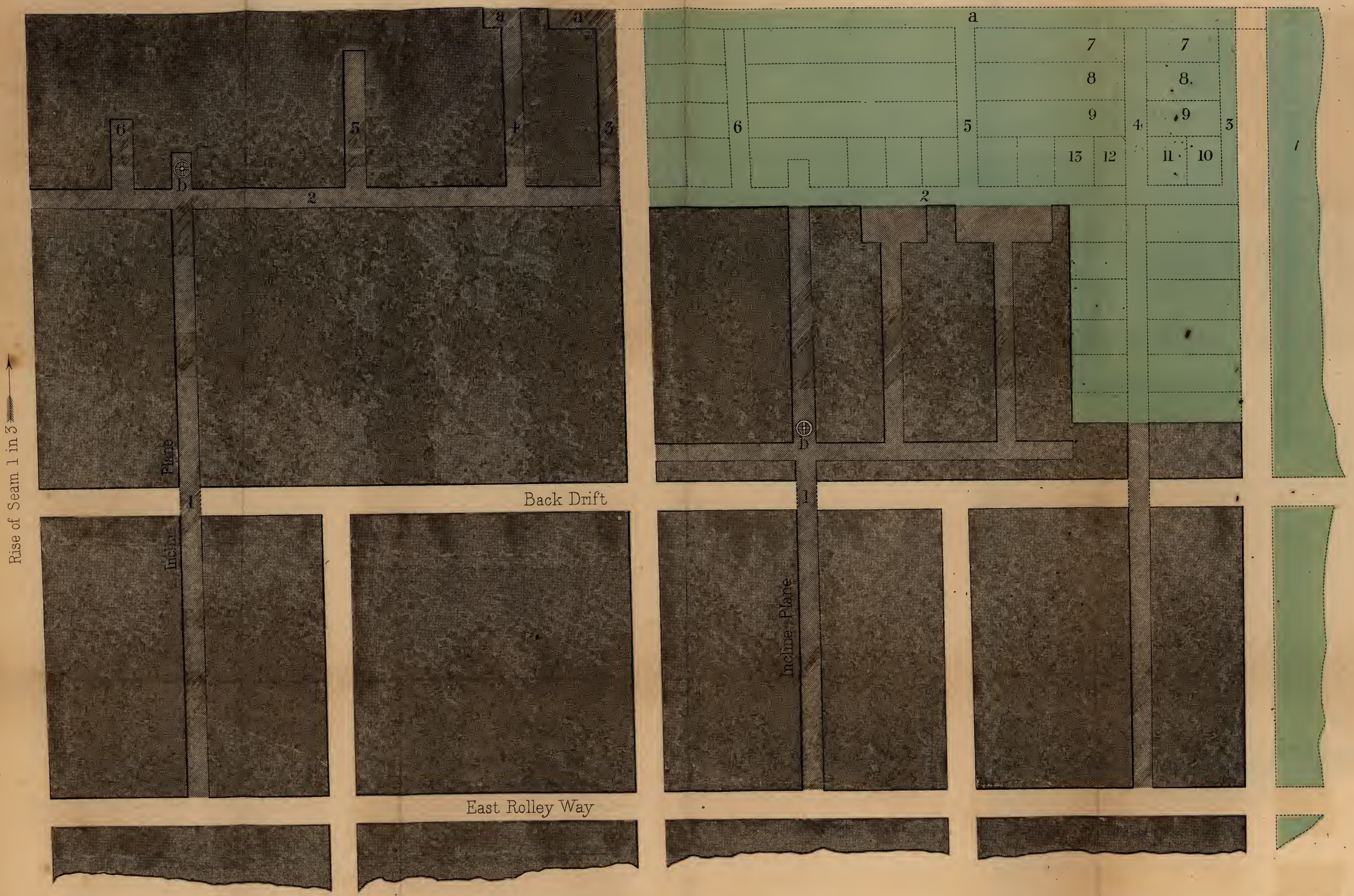
KILLINGWORTH COLLIERY

South East Division.

High Main Seam Pillar Workings.



Scale 10 Yards to an Inch.

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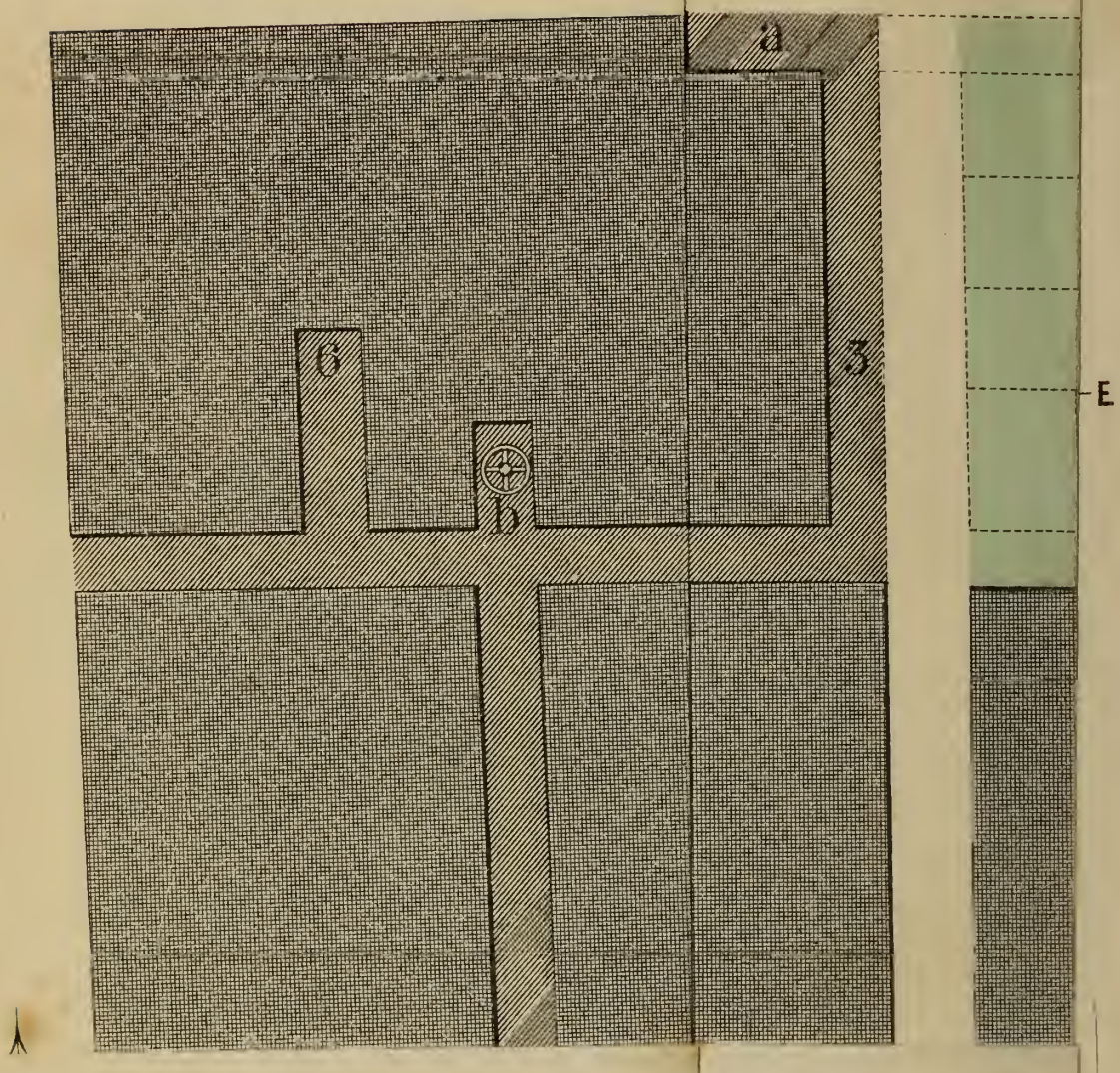
ATE VII.

South

High Main Sec



were removed without the least disturbance, but, we found, after making a large goaf, which did not fall freely, the post roof resting upon the metal ridges* seemed again to cause a movement of "creep," but only in a slight degree.

Plate V. North-east Division; Seam, six feet thick; depth about fifty fathoms; old pillars twenty-six yards by seven yards; bords and walls heavily fallen. A wall, 1, is driven across the middle of every third pillar and jenkin, 2 up the middle to goaf, the sides, 3 and 4 of each pillar, being brought back down the jenkin to stooks 5, 6, which are then removed. A thin shell of coal is left on each side of the pillar to keep out the fallen stone, causing a loss of eight or ten per cent. of the pillar, and six per cent. of the whole area of coal.

Plate VI. North-west Division; Seam, seven feet thick; depth 180 fathoms; post roof; large pillars, fifty yards by thirty-three yards. The process of working off these pillars is extremely simple; a four-yard wide jenkin, 1, is driven half the length of the pillar, on each side of the headways course, leaving a lift of four yards on the high side next the goaf. Then, siding up, 2, to goaf, and the four yards of coal, 3, brought back to stook 4; as soon as both sides are off to the stook they are removed. Nearly all the coal is obtained, not more than two per cent. being lost, so effectually, indeed, that instances have been seen where the post roof has broken off, as if sawn asunder from the main body, and slipped down, a huge mass, at the edge of the goaf, showing a perpendicular wall face.

Plate VII. South-east Division; Seam, eight feet high; depth about 200 fathoms; large pillars sixty-six yards by fifty-five yards. The pillar is divided into divisions by walls driven to the rise, each of these is converted into self-acting inclined planes, as circumstances may require. The rise of the seam being so great, the temperature of the working places often high, and the large quantity of hydrogen gas evolved, imperatively require an airway, *a*, *a*, to be driven round the outer and rise side of the pillar for ventilation.

Plate VII. represents the removal of the first pillar adjoining the rolleyway. Wall 1 is driven up, the coals being inclined down by a "dilly" weight, which, I believe, has been before described in the "Transactions" of the Institute; but for the benefit of those who may

* Metal ridges, or "metal riggs," the portion of bottom stone or coal forced into the old workings by the creep.

not be enabled to refer to it, I may briefly describe it as a heavily-weighted box, on a tram, running on a tramway of its own. This serves as a counterbalance weight. It draws up the empty tub to the face by means of a hemp rope passing round a portable sheave, working in an iron strap, and secured to a prop, which, of course, is moved forward as the working place advances. The loaded tub counterbalances the dilly weight, when hung on, and takes it up again in turn, and so on alternately, the loaded tub pulling up the dilly weight, and the dilly weight pulling up the empty tub.

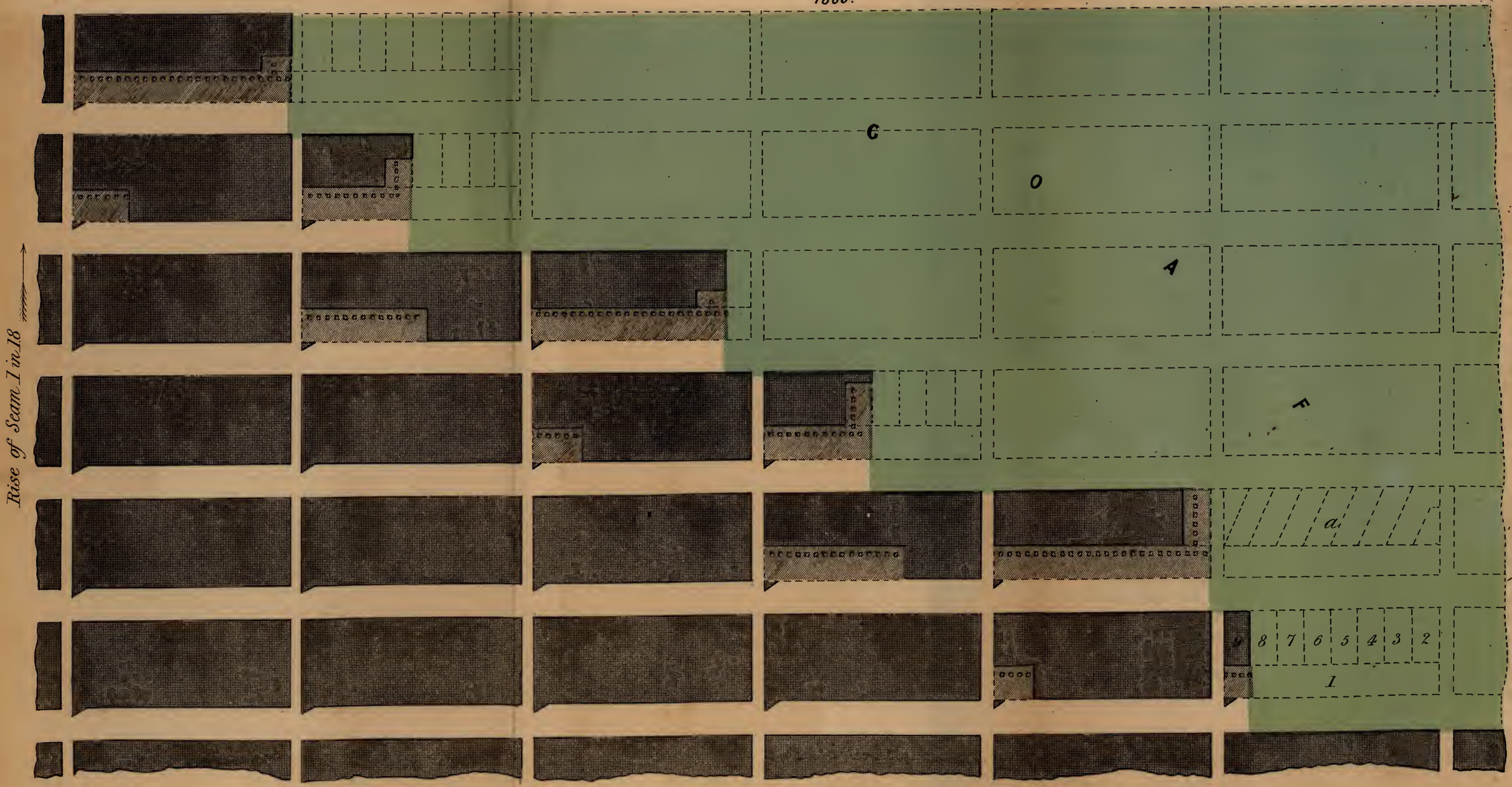
When wall 1 is about twenty yards from the top of the pillar, an incline wheel, *d*, is fixed for the top of the pillar, as shown in the west pillar, and at *d* in the east pillar, for the lower portion of the pillar. A narrow bord, 2, is driven to the outer edge, from whence is set away walls 3, 4, 5, 6, and the airway *a*. The coal is taken off in four-yard lifts out of each wall, bordways way on the level line of the seam, as 7, 7, 8, 8, 9, 9, a shell of coal, about two feet thick, being left on the side next the goaf for protection, a great portion of which is afterwards worked off. This district is nearest to the great dyke. The bottom of the post is very undulating, rising and falling in heavy rolls, the spaces being filled up with dark grey metal stone, which is often difficult to keep up, and making heavy falls. This is the reason why the same system as shown at plate VI. is not followed, the lifts having to be wrought out quickly. Large areas are often excavated before the post is broken down, which causes the bottom to creep about the broken workings and become troublesome, but not more than we can successfully contend against. The lowest piece of coal next the wall is taken off, as 10, 11, 12, 13, either headways or bordways, as it can be best obtained. I estimate the loss of coal in this division to be about 5 per cent.

It is the invariable custom in the North of England always to use the Davy-lamp where the least danger is to be apprehended in pillar working. It is used in the least dangerous parts of Killingworth Colliery; but in the dip and most dangerous parts, no other but the "Geordy," or Stephenson's safety-lamp, is allowed to be used, as being the most improved, and affording greater protection from danger than the Davy. The Davy safety-lamp is undoubtedly safe under all ordinary circumstances of danger; but on extraordinary occasions, where danger is constantly to be apprehended, I prefer the "Geordy." I mention this from having observed, in persons unaccustomed to the use of the "Geordy," a species of objection, almost amounting to a prejudice,

SEATONBURN COLLIERY.

Low Main Coal Seam Pillar Workings.

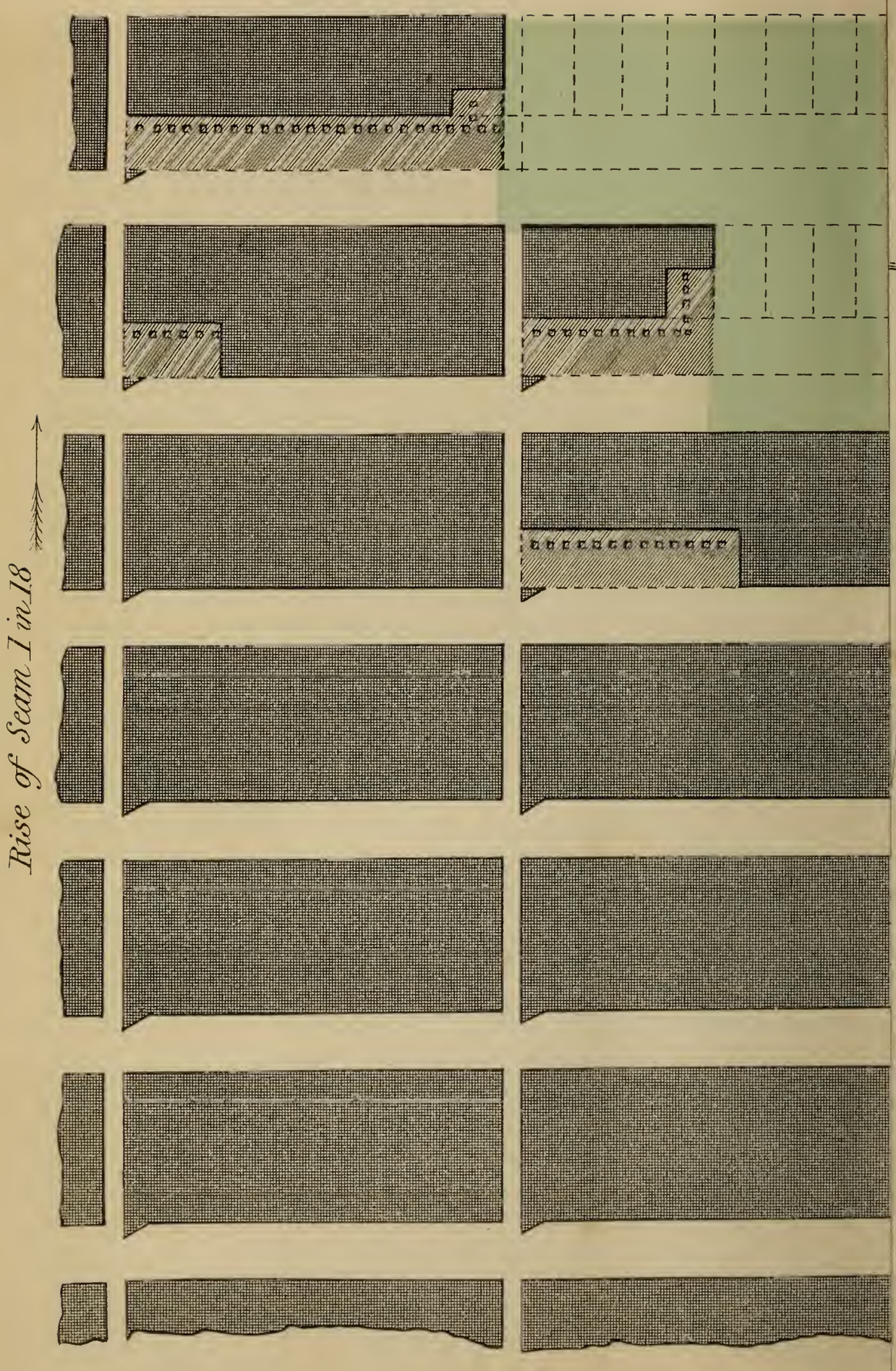
1860.



(Proceedings N° of E.I of M.E. 1860 I.)

Scale 20 yards to an Inch

Lithographed by A.Reid, Newcastle.


Rise of Seam 1 in 18

against this safety-lamp, difficult to account for, unless they are ignorant of the principles and action of the lamp. As the "Geordy" is not so generally known and extensively used as the Davy, I may here give a brief explanation of its action, and why I prefer it as above stated. When introduced into an explosive atmosphere, the light gently flames up, and is immediately extinguished. The reason of this is, the flame absorbs all the oxygen inside the glass cylinder placed within the gauze, and the air cells at the bottom, to admit air for the support of the flame, being too small to allow a sufficient quantity of oxygen to pass through for supporting a large flame, it is necessarily and immediately extinguished, the heated air passing upward preventing a supply from the holed cap on the top. This is not the case with the Davy safety-lamp. Every orifice of the gauze being open for the admission of oxygen from the surrounding air, a sufficient quantity is admitted to support a large flame; and when introduced into an explosive atmosphere, it flames up, and continues burning with a large volume of flame as long as any oxygen remains, so as to render the gauze red hot, if the lamp is continued in such an atmosphere. In the ordinary course of working it is not, however, allowed to remain in such an atmosphere until it becomes red hot, the workmen being ordered to remove it. I merely state this, contrasting the value of the two lamps in an explosive atmosphere, the utter inability of the workman to remain at work, *in the dark*, under such circumstances, with a "Geordy" lamp, which he might be tempted to do with a Davy.

I shall now offer a few remarks on pillar working in a hard coal seam, plate VIII. The Low Main Seam at Seaton Burn Colliery is found at a depth of fifty-eight fathoms, but, from the rise of the seam, and the great number of faults, the depth is variable, the seam generally four feet thick, and very hard in its nature. Roof, blue metal stone, with post girdles, bottom, grey metal stone, varying in thickness from a few inches to twelve inches; beneath this stratum, however, there is a strong grey post, which really forms the bottom or substratum of the seam. Pillars, forty yards by sixteen yards; the bords are turned away four yards, and thrown out to six yards wide. The process of removing the pillar is simply by driving a six-yard jenkin, 1; by the side of the old bord, a road is supported by placing chocks, four feet from the side of the coal, headways lifts are then sided off, as 2, 3, 4, 5, 6, 7, 8, the last stook, 9, being removed from the headways course. Occasionally there is a crosscut or diagonal cleavage in the coal, the line of this is usually

followed by the lifts shown at pillar *a*. The bottom being firm there is not the slightest indication of creep. The coal is all worked away, none being lost except that which may be left as bad or inferior in the neighbourhood of hitches.

It is extremely difficult to make dry practical details generally interesting, but, if I have succeeded in making my communication useful, I shall be amply repaid.

DISCUSSION ON MR. CRONE'S PAPER.

Mr. Taylor—Alluding to the mode of working explained by Mr. Crone in plate III.—By working this way you get a fresh roof every day, if you persevere.

Mr. Crone—That is if you have a binding roof.

Mr. Daglish—You cannot remove the chocks with such a roof, if you were to work with chocks.

Mr. Taylor—The plan has never been carried out in this district.

Mr Crone—Breakers are formed between the chocks and the face of the coal.

Mr. Taylor—That is more likely to happen where it is a tender roof. A tender roof bends down. Have you any band in the seam?

Mr. Crone—None. Large pieces of coal would have to be used to keep it up. The height of the seam is an objection. The height is five feet six inches, and it would take a good many chocks to fill up the space to be kept open for the workmen.

Mr. Berkley—There is no whole roof. No timber could stop it from falling.

Mr. Crone—There is no bed of stone you could timber against that would resist the pressure.

Mr. Taylor—Was any whole coal left?

Mr. Crone—No; the pillars were of small dimensions.

The President—Twelve feet between them?

Mr. Crone—Yes; loose, black short stone.

Mr. Southern—The falling of the shale would never be sufficient to allow chocks to be used, where the roof is so very short.

Mr. Ramsay—Did you ever try to let the stone fall down and bring the Five-Quarter coal back above the working of the Brass Thill coal?

Mr. Crone—No; there is too much space between the two beds of coal. The falling mass of *debris* would fill up the places completely. You can hardly get the props out. There are a great many open fissures.

Mr. Taylor—Were these fissures in the shape of steps?

Mr. Crone—They were vertical cracks. The line of the roof and the bottom of the seam were level. There was no slip. There was merely an opening. He had seen them nearly an inch wide. It was rather a tender seam. The bords were usually driven four yards.

The PRESIDENT—You say by the last mode you pursued you lost only twelve per cent. What per centage do you lose in the other modes?

Mr. CRONE—I often used to lose one-fourth. The roof was so heavy in the old system of jenkining, the top frequently rushed in. The coal was not worth ridding for. In the improved mode we invariably tried to remove all we could. We were never disturbed by creep.

The PRESIDENT—There could not be a more difficult case of working coal, with a bad roof, and only ten feet to another seam, and that seam worked, and the seam below worked in the pillars likewise.

Mr. RAMSAY—Was it free from water?

Mr. CRONE—We had water to a trifling extent.

[The discussion was then taken on the working of the High Main Seam at Killingworth, "North-west Division."]

The PRESIDENT—Did you, in working these pillars, get all the coal left?

Mr. CRONE—Yes, nearly so. We found the metal ridges of the bords formed pillars to support the roof. We were afraid to take the whole of it out altogether on account of the gas, and the stones and rubbish falling into the working places, but we got almost the whole of the coal.

The PRESIDENT—I was at Killingworth when the whole coal was worked. It was an illustration of the mode of working the coal at the period when the pillars were formed. Previously to that, and where the depth was not so great, it had been the custom to reduce the size of the pillars, leaving as much as would support the roof, and not bring on a creep. The pillars were reduced at the top—four yards were generally taken away and they were so left, the impression being that no more could be got. Lamps were not then invented; the ventilation was required to be perfect so as to admit the use of candles, and, therefore, this is a case where, for want of lamps, a large portion of coal was left. It was the same in the pillars you mention. There was a great deal of gas, and the question was, what quantity of coal could be got out without using steel mills, and to keep the ventilation intact. That mode was practised over a very great district of country, viz., to leave as much coal as that a creep could not take place. Since lamps have been invented, all these pillars have been got out most successfully. In the case you allude to, a creep took place after the pillars were drawn up by water, the pillars being just sufficient to support the roof. The water

percolating the fireclay, a shale in the bords produced disentegration of the shale, weakening the base of the pillars, and producing a creep. The metal ridges, or upheaved sill of shale in the bords, forming the roof of the mine; and it appears all the coal, except a small per centage, has been since got. In some cases we took part of the coal of the pillars away where we found the coal that was left more than sufficient to support the roof—all that we could get with candles—leaving what was necessary to keep up the ventilation.

[Mr. CRONE here read his observations "On the North-west Division."]

Mr. DAGLISH—Why cannot you carry the jenkin up to the goaf?

Mr. CRONE—Because we would have to leave a shell at the side of every lift to support the falling stone on the rise side of the jenkin.

Mr. DAGLISH—Did you not say you did leave a portion of coal?

Mr. CRONE—It falls for all that. If taking it off close, we should leave a foot thick, but, by driving a jenkin of four yards wide, we should leave two thin strips of coal. The height of the seam is extremely dangerous; it lessens the danger to leave a wide jenkin.

The PRESIDENT—You drive the jenkins four yards?

Mr. CRONE—Yes; it is hard coal, but it contains a very large amount of gas. The pressure of gas assists much in working the coal. Being a post roof, and a great depth, there is a considerable amount of weight on the coal, and this, assisted by the gas, renders the coal easy to work.

Mr. SPENCER—You got the timber easily out?

Mr. CRONE—There is a thin bed of block shale between the roof of the coal and the bottom of the post, which falls when the timber is removed.

Mr. DAGLISH—The great advantage of this system is owing to the height of the seam. The other particulars of the case are almost identical with ordinary working. You could not work so unless you used lamps.

Mr. CRONE—It is a heavy rise, and the seam is of great thickness. This necessarily compels us to adopt that system which we find the best. If it were a level seam, or comparatively level, it would be a different thing altogether.

Mr. RAMSAY—The roof stands, in the first instance, until you produce a general fall by working out a considerable breadth of coal?

Mr. CRONE—It frequently stands. If we do not get the roof down it produces a creep, and teazes us very much,

[Mr. CRONE then read his remarks on the "South-east Division."]

Mr. SPENCER—What is the least inclination these dillies can be satisfactorily applied?

Mr. CRONE—We seldom think of applying them less than eight inches to the yard, where the borings have a difficulty in getting up even a short distance. If the seam has not a very heavy rise we work with ponies.

The PRESIDENT—When I stated that in some parts of Killingworth Colliery the pillars were left in that state that would or might produce creep, in that portion of the colliery there was not a very large quantity of gas, and we got the places pretty well ventilated in the ordinary manner, so as to be enabled to use candles; but, in another part—the eastern portion of the colliery—there was an immense quantity of gas. We could not, in that case, take away the coal to produce creep, for this reason it was necessary, after airing one bord, to take the air into the back pillars, to dash the air or mix the gas with the common air before you could take it into the next bord. It was necessary, therefore, to keep open a considerable extent of back pillars, or waste, in order to be enabled to so mix the air, almost explosive in that portion next the roof, with the common or lower stratum of air, so as to render the whole inexplosive, before you could use it in the next bord. We had to take it often fifteen or twenty pillars down into the waste before we could take it into the next working bord, otherwise we could not use the candles, and there were no lamps then.

Mr. DUNN—(To Mr. Spencer)—In the neighbourhood of Crook was not the mode of working affected by the state of the surface?

Mr. SPENCER—We try to get as much of the coal away as possible.

Mr. DUNN—When I went into the Auckland district, twelve years ago, they left a small pillar, not to destroy the land.

The PRESIDENT—The pillars were taken away at a very early period. I have reports as far back as 1740 or 1750, and upwards, as to the mode of taking away the pillars, and have travelled in Old Benton waste when large districts of pillars have been worked entirely away. Benton was abandoned sometime before 1765, so that before 1765 there must have been a very extensive system of taking away pillars. If you inquire of old people, they say it was the practice to leave pillars till they got to the extremity, and then they came back and took them away. The records of the very old collieries show that it was the practice to take away pillars.

Mr. DUNN—My remark refers to shallow districts. They left the pillars for fear of destroying the land.

The PRESIDENT—The great difficulty, before the lamp was invented, was to know how much you could take away with candles, and whether, after taking away a certain quantity, you could take away more without producing a creep. I have several reports on the subject. I do not know whether any general system could be laid down as to working pillars, or working coal by the pillar and stall method; cases such as Mr. Crone has instanced are exceptions. At Dipton they have a very bad roof, and the circumstances are, also, exceptional. But it has always appeared to me, now they have access to any part of the mine with safety-lamps, that if they left pillars at all, these pillars should be sufficiently strong, that in any mode of working them the part left should be sufficient to support the roof, or superincumbent strata, without crushing the coal. They knew that before they could take pillars off a much less strength of pillar would do than after they produced a break in the strata. After the break a portion of the support was gone. The pillar, in that case, must be stronger than if no such break had taken place, and, as in every case of working pillars, such a break does take place, it follows that the pillars must be much stronger than barely sufficient to support the superincumbent strata. Suppose they began at the end of the pillar and took a portion of it away. In every stage of working the pillar, the coal left in such pillar should be strong enough to support the roof without crushing the coal. That is the only general principle which can, in my opinion, be laid down in pillar working. If you drive a jenkin you leave a weak pillar on each side, but that which is left should be sufficiently strong, so that the coal is not crushed.

Mr. SPENCER—In all the places I mentioned the roof has broken immediately, so that there is no weight at any time on the coal.

The PRESIDENT—You should never have the pillars in such a state that the superior strata crushes them.

Mr. SPENCER—The cleaner the coal is taken out the less is the damage done to the surface. When it is clean taken out it falls evenly.

The PRESIDENT—I quite agree with Mr. Spencer in that. They lower the surface, but it is not broken up into hollows.

Mr. Steavenson then read the following supplementary paper, and gave drawings of the different descriptions of oven, in accordance with the request made to him at the last meeting.

FIG. 1.

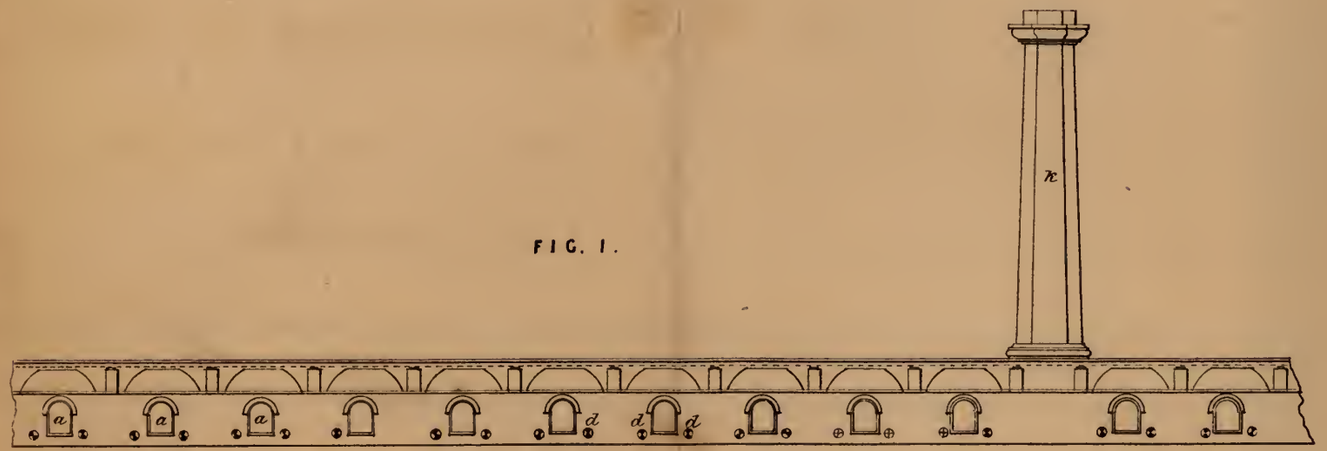
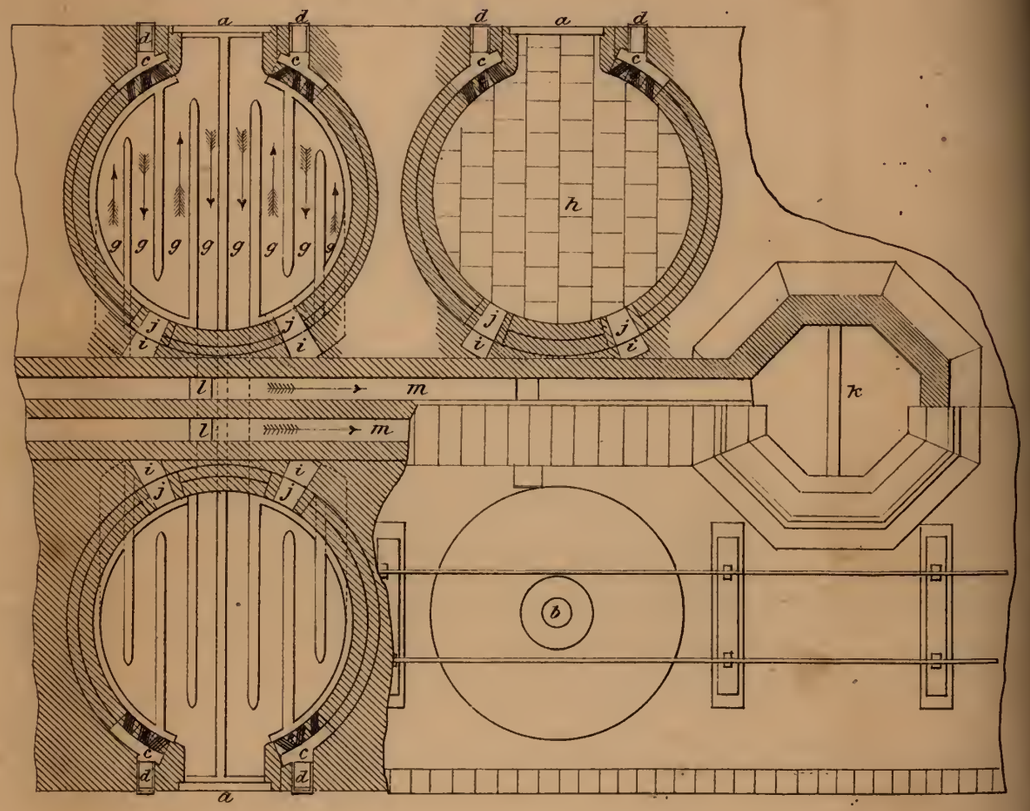


FIG. 2.



Scale of Fig. 1. ¾ of an inch to 5 feet
" " Figs. 2. 3. 4. 5. ¼ of an inch to 1 foot

FIG. 3.

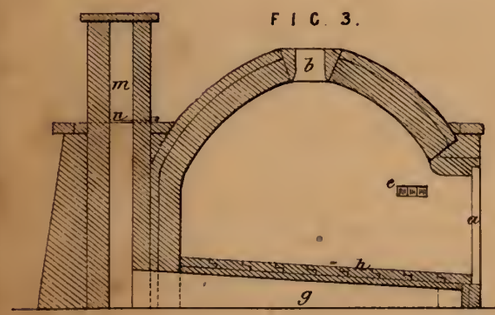


FIG. 4.

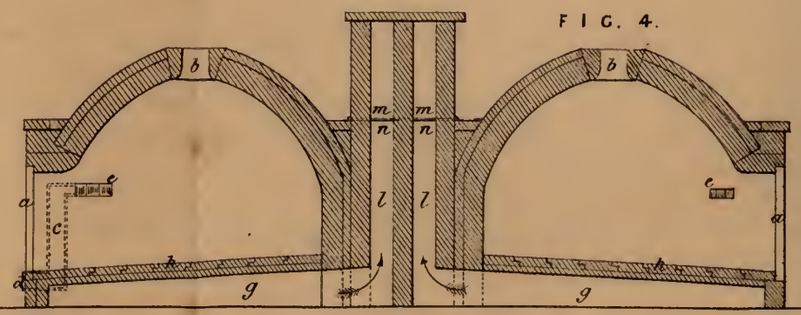
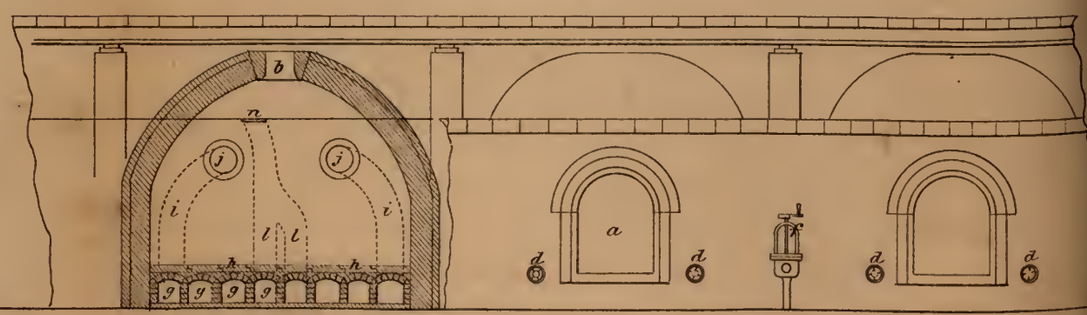


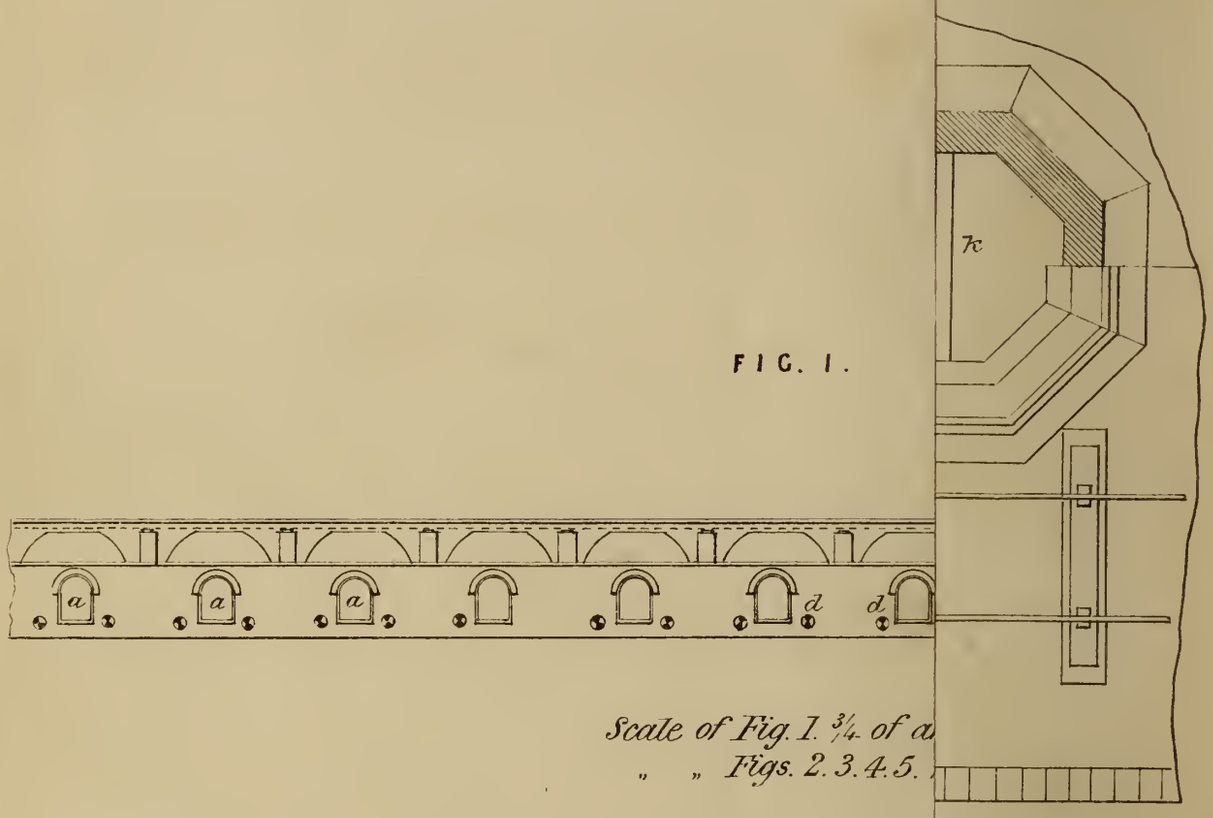
FIG. 5.



Lithographed by A. Reid, Newcastle

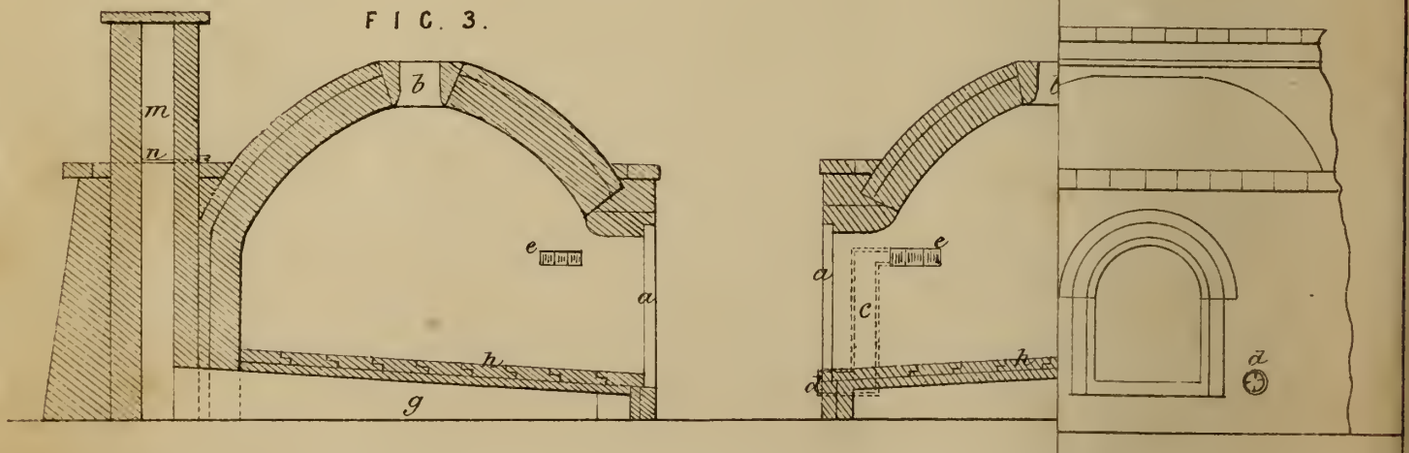
PLATE I

FIG. 1.



Scale of Fig. 1. ¾ of a
„ „ Figs. 2. 3. 4. 5.

FIG. 3.



ithographed by A. Reed, Newcastle

SUPPLEMENTARY PAPER

ON

THE MANUFACTURE OF COKE

IN THE

NEWCASTLE AND DURHAM DISTRICTS.

By Mr. A. L. STEAVENSON.

Having been requested to obtain and place on record certain inventions and improvements in coke manufacture and coke ovens, I have selected the following as illustrative of the degree of perfection to which the art of coke-making has attained at the present time. The remarkable similarity of several of which I will instance, shows the necessity for such a registration.

First, I will notice certain patents having for their object the utilization of the heat afforded by the ignited gases, which are generally allowed to pass directly into the chimney or open air.

The invention of John Robert Breckon and Robert Dixon consists in constructing ovens with one, two, or more flues, for the purpose of conveying the gases, when in a state of combustion, underneath the floor of the coke ovens.* The flues communicate with the interior of the oven, and the gases are conveyed through them underneath the floor of the oven, and afterwards into a chimney.

The accompanying plan, and following description, will enable the method to be better understood. (See plate I.)

Fig. 1 is an elevation of a row of coke ovens, with a chimney, into which all the products of combustion are conveyed.

* See specification in pursuance of the conditions of letters patent, filed June 9, 1860, by John Robert Breckon and Robert Dixon.

Fig. 2 is a plan, partly in section, of four coke ovens.

Fig. 3 is a sectional elevation, taken through the door of the oven.

Fig. 4 is a sectional elevation of two coke ovens, with the flues leading to the chimney.

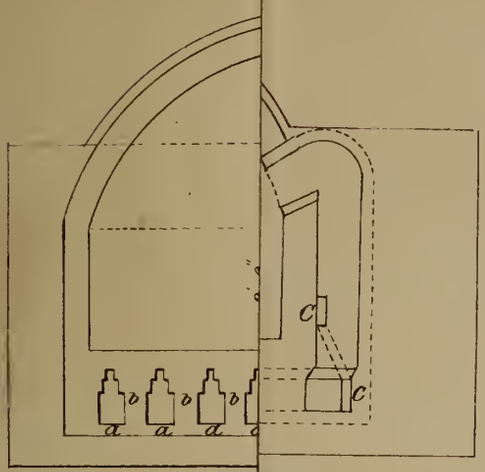
Fig. 5 is another elevation, also partly in section.

These ovens are shown with regulating valves and air distributors, for which letters patent were granted on the 29th of March, 1858. But the present invention may be used independently of such regulating valves and air distributors. *a* is the door of the coke oven; *b*, the opening at the top; *c*, the flues or pipes which convey the atmospheric air admitted by the regulating valves *d*, to the distributors *e*, *e*; *f* is the water tap.

The present improvement consists in the application of flues *g*, *g*, which are placed under the floor, *h*, of the oven. The floors are of fire brick or other suitable material, and bear on the partitions between the flues *g*, which are connected with the interior of the oven by the upright flues *i*, *i*, and orifices *j*, *j*, and with the chimney *k*, through the vertical flues *l*, and horizontal *m*. Each orifice, *j*, is in communication with one of the outer flues, *g*; and as the partitions between the flues terminate alternately at a certain distance from the inner wall of the oven, it is evident that a passage is left for the gaseous products of combustion to pass from one flue to another, as indicated by the arrows in fig. 2.

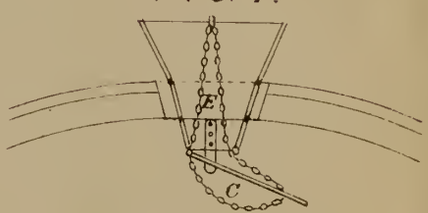
When these gases arrive at the inner flues *g*, they rise up the flue *l*, and enter the horizontal flue *m*, which conveys them to the chimney *k*; a damper, *n*, is placed in each flue *l*, so as to be able to shut off any one or more of the coke ovens during repairs, or for other purposes, without interfering with the others. The coal to be converted into coke is dropped into the oven through the opening *b*, or it may be cast in through the door *a*.

When the coal is ignited, the gaseous products of combustion escape through the orifices *j*, and down the flues *i*, into the flues *g*, *g*, through which they circulate before escaping up the flues *l*, and along the flues *m*, to the chimney *k*. By this means the floor of the coke oven is heated by the ignited gases, which, the patentees state, enables them to convert a given quantity of coal into coke in about one-third less time than is required in the ordinary coke oven, and to obtain from ten to fifteen per cent. more coke, and the coke produced is denser and of a better quality. They do not limit themselves to the details given, as the shape of the coke oven may be oval, instead of circular, as shown, and the number of



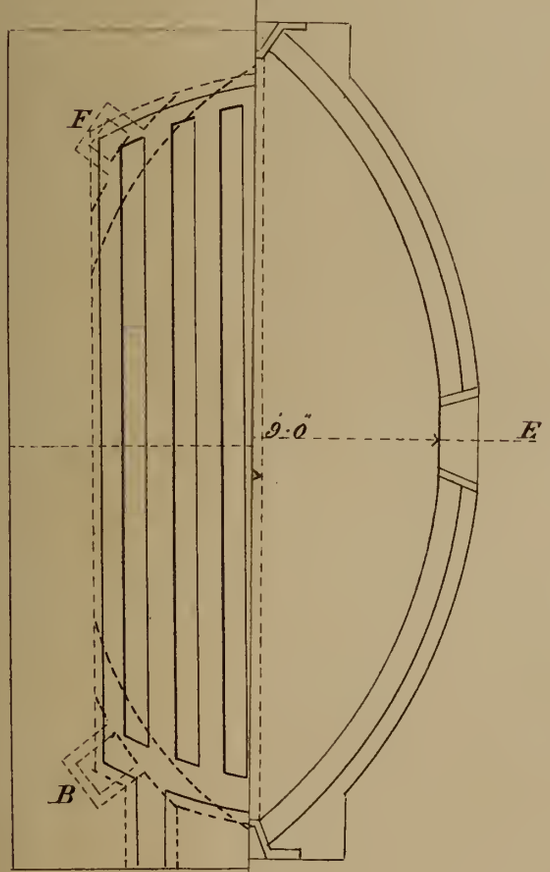
Trans. Fig. 4.

FIG. 7.



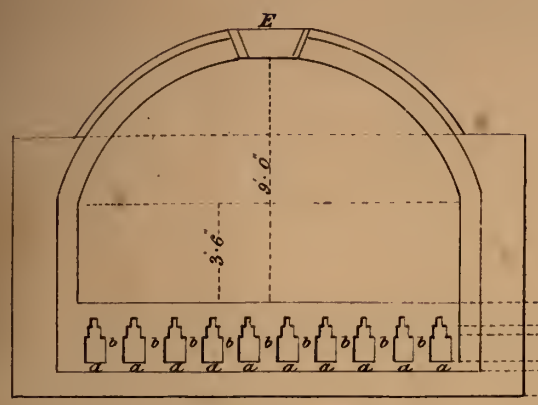
Machine for filling oven.

6



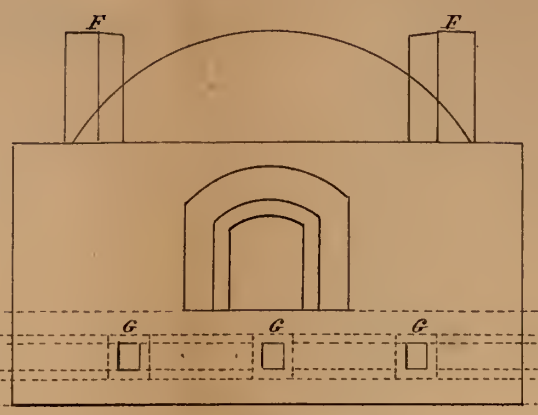
Plan of on.

FIG. 1.



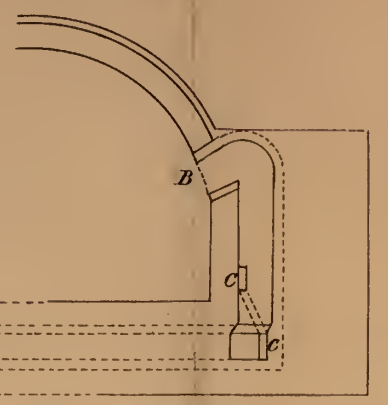
Transverse Section.

FIG. 2



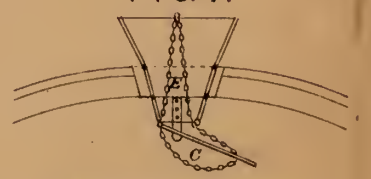
Front Elevation.

FIG. 3.



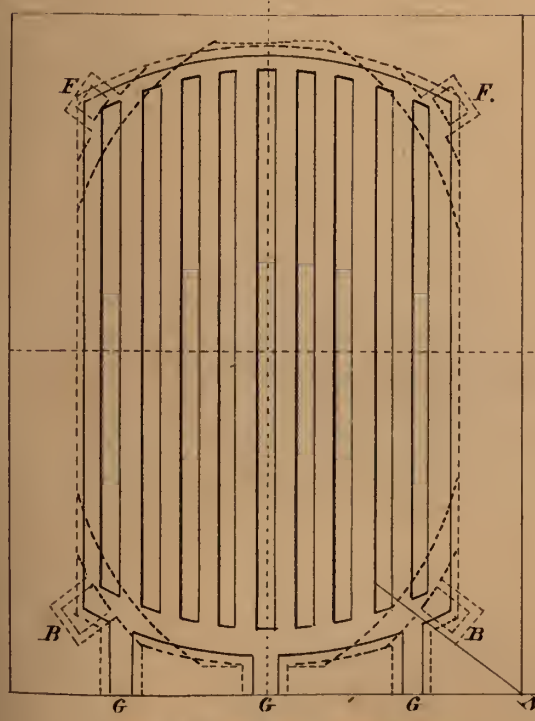
Section at N. Fig. 4.

FIG. 7.



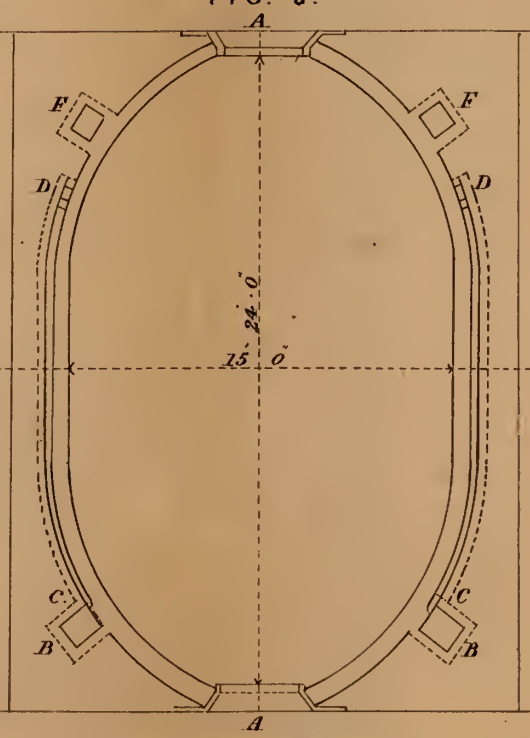
Machine for filling oven.

FIG. 4.



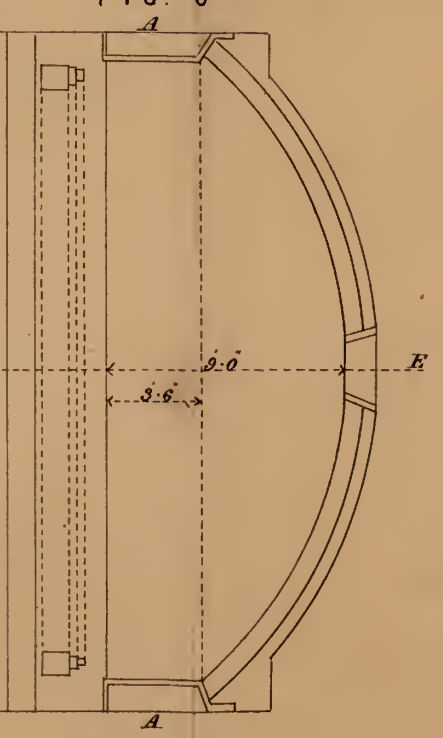
Plan of Flues below bottom of oven

FIG. 5.



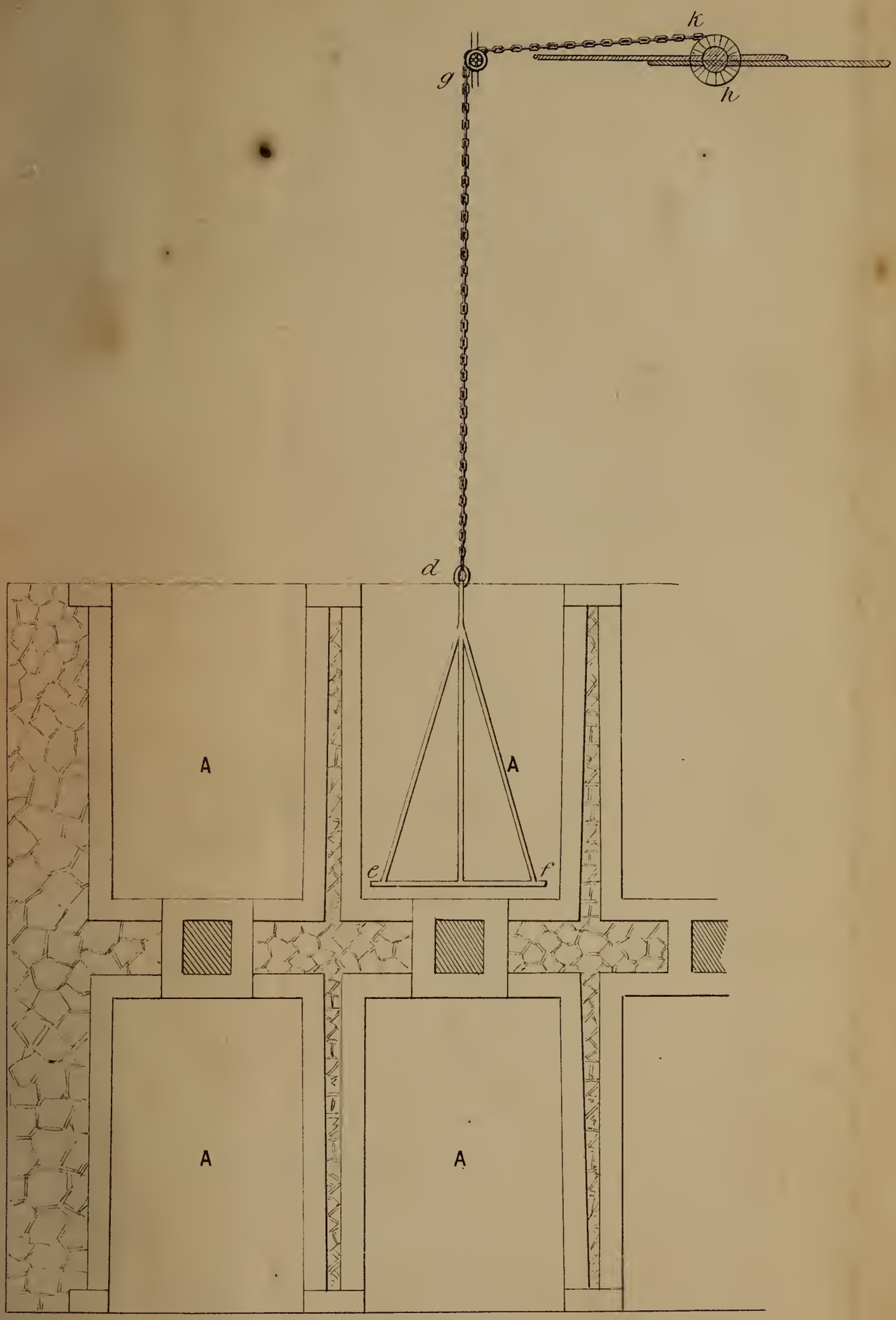
Plan of bottom of oven

FIG. 6



Longitudinal Section.

Scale 10 9 8 7 6 5 4 3 2 1 0 10 20 30 of Feet

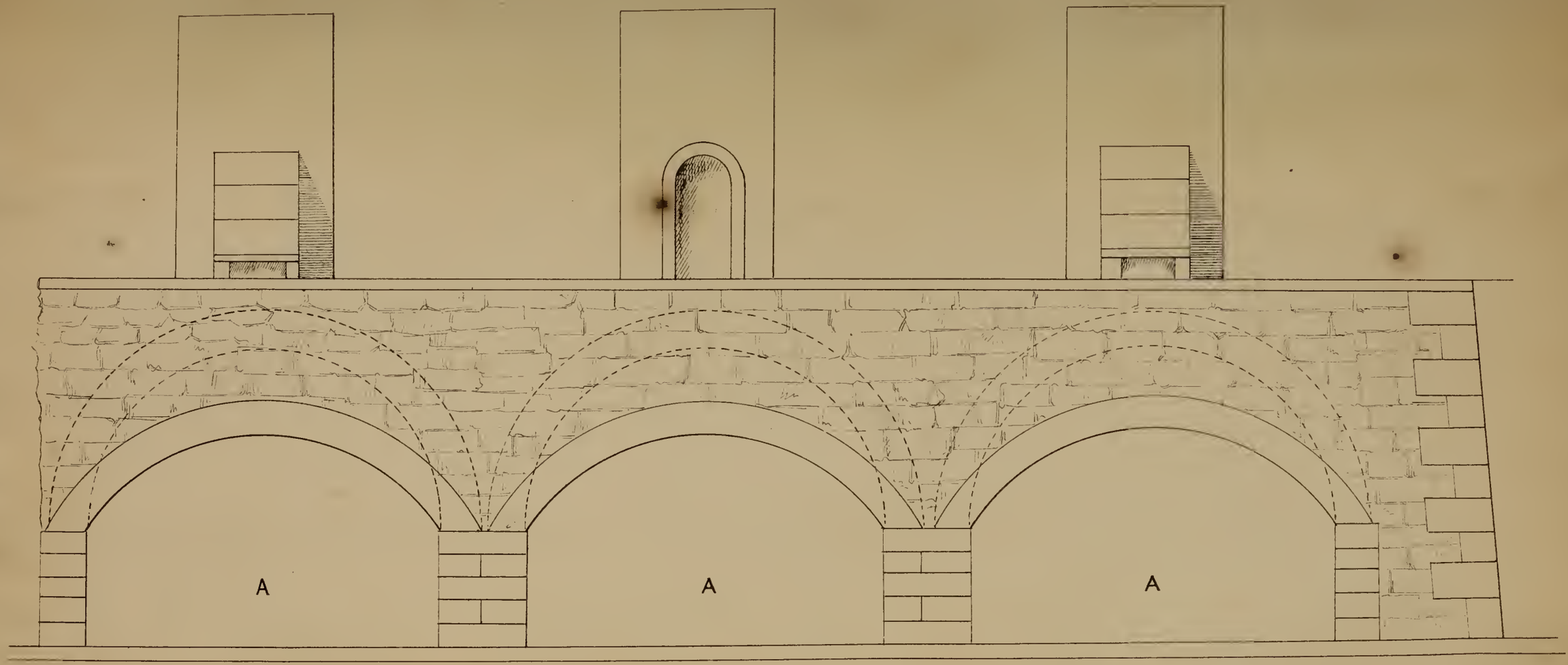


GROUND PLAN
of
ANCHOR OVEN.

Scale 4 Ft. - ½ Inch.

Lithographed by A. Reid, Newcastle.

PLATE, IV.

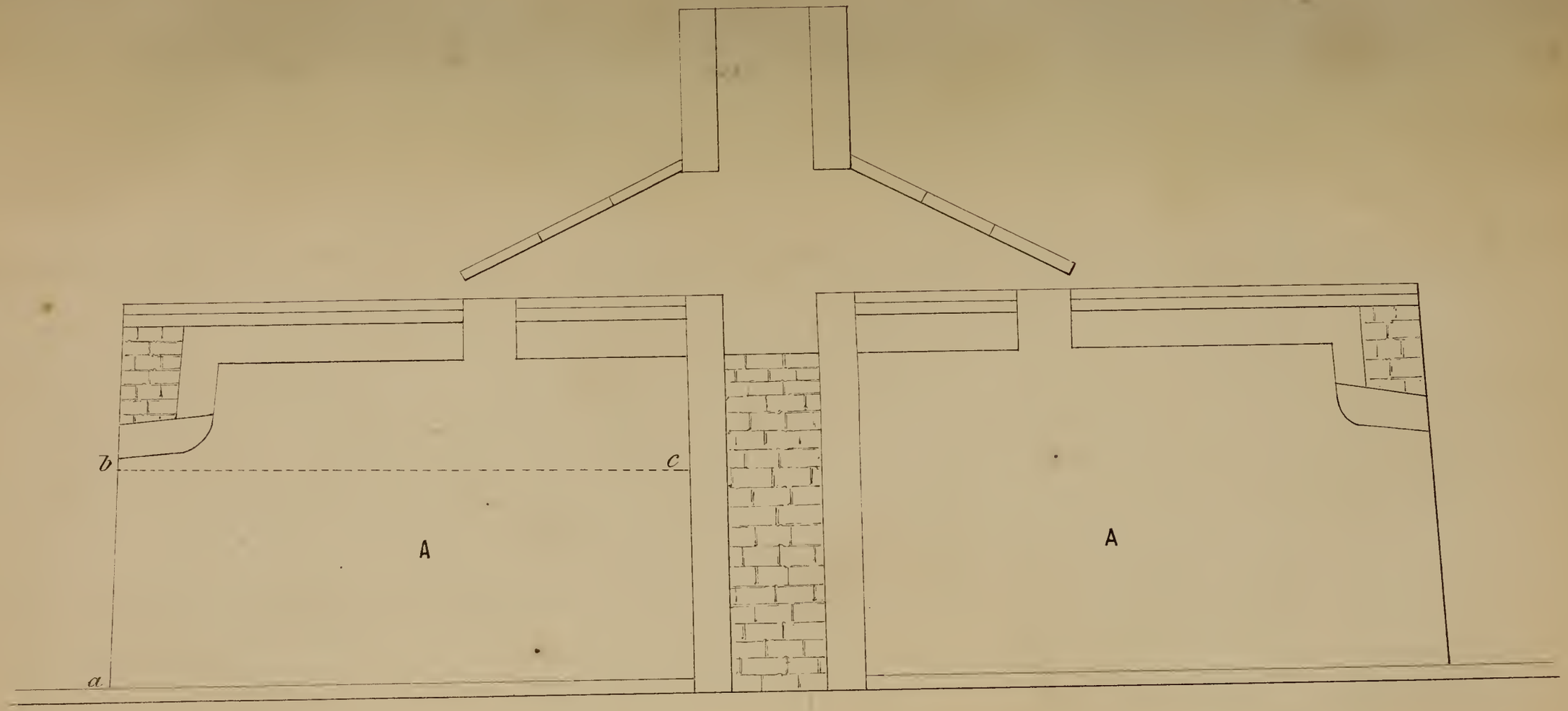


FRONT ELEVATION
of
ANCHOR OVEN.

Scale 4 Ft. -1 Inch

Proceedings N° of E. I of E. 1860-1.

PLATE V.



SECTION
of
ANCHOR OVEN

Scale 4Ft. -1Inch

Proceedings N° of E. I. of E. 1860 I.

Lithographed by A. Reid Newcastle

flues, *g*, may be considerably varied, but claim as their invention an improved arrangement of flues for heating the floors of the coke ovens, by means of the ignited gases escaping from the coal during the process of coking. A very similar patent was taken out by Joseph Dunning, in May, 1853.*

The oven is constructed of the shape and dimensions shown on the accompanying plan, plate II., in which the interior of the oven (see fig. 5) is twenty-four feet in length and fifteen feet in breadth, measured on the floor of the oven, three feet six inches high from the floor (see fig. 1) to the springing of the arch of the roof, and nine feet from the floor to the crown of the arch (see fig. 1); and for the purpose of facilitating the process of coking, and the subsequent drawing of the coke from the oven, two doorways and doors of the usual material and suitable dimensions are made, one at each end of the oven, as shown at A, A, in figs. 5 and 6.

Instead of allowing the heat, arising from the ignited coal in the oven during the process of coking, to pass away at the top or back of the oven, through a flue leading directly into a chimney, it is made to circulate under the floor, and along a part of the sides of the oven, by means of two vertical flues, one at each corner, at one end of the oven, having their upper orifices in the interior of the oven a little above the springing of the arch of the roof, as shown at B, fig. 3. These two vertical flues, of about fourteen inches square, sectional measure, are carried down in the substance of the side of the oven, and close to the usual firebrick lining, as shown at B, fig. 3, and B, B, fig. 5, and made to open (see B, B, fig. 4) into, and communicate with, a series of horizontal flues under the floor of the oven, (see fig. 4, which is a plan of the series of horizontal parallel flues running lengthwise under the floor, connected and communicating with each other by means of two horizontal curved cross flues of similar size.) These horizontal flues are made in the substance of the floor of the oven about nine inches wide and eighteen inches deep, the parallel straight flues being separated from each other by walls about nine inches wide (as shown in section in fig. 1, in which *a*, *a*, is a section of the flues and *b*, *b*, a section of the walls), and the whole series of horizontal flues is to be constructed at such a depth below the upper surface of the floor as to make the floor above these flues about six inches in thickness. There are also constructed, in the sub-

* See specification of Joseph Dunning, of No. 14, Regent Street, in the city of Westminster, architect, sealed 31st May, 1853.

stance of the two longer sides of the oven, two horizontal flues, viz., one on each side, fourteen inches deep and four inches wide, at such a level that their bottoms may be about two inches above the level of the floor, opening into and extending from the two vertical flues (B, B, fig. 5) to about two feet from the two chimneys hereafter described, as shown by the dotted lines from C to D in fig. 5, and connected at their ends, D, with the horizontal flues under the floor of the oven by descending flues of the same sectional dimensions, as shown in section at C, C, fig. 3, in which C represents a section of one of these horizontal flues, and the dotted lines from C to C a section of the descending flue, connecting this horizontal flue with the series of horizontal flues under the floor. At that end of the oven opposite to the two vertical flues above mentioned are constructed two straight vertical chimneys, of about fourteen inches by nine inches, inside measure, communicating with and opening into, at their base, the horizontal flues already described, in the position and manner shown at F, F, in figs. 4 and 5, and rising to any convenient height above the exterior of the roof of the oven, as shown at F, F, fig. 2.

An oven thus constructed may be charged with coal in the usual manner, but it is recommended that the coal should be introduced through an opening at the top of the oven, as shown at E, figs. 1, 6, and 7, and for the more easy spreading of the coal evenly over the floor, the use of a hopper, having below it an inclined board, of length and width suitable to the size of the oven, moving at one end on an axis, C, fig. 7, so that by means of chains attached to each side of the bord, and by pulleys suitably fixed at the bottom of the hopper, as shown in fig. 7, the coals may be projected on to the floor at any angle, in the direction of each of the doors.

When the oven has been charged and the coals ignited in the usual way, air is admitted by the doors to carry on the necessary combustion. The heat, gas, and volatile matters produced will then rise into the interior of the oven above the charge of coal, and pass down the two vertical flues above described into the horizontal flues in the sides and under the floor of the oven, and thence so much as may be necessary for creating a sufficient draught of air for carrying on the requisite degree of combustion must be allowed to escape upwards through and out of the two chimneys above described, the draught being regulated by moveable fireclay tiles placed on the tops of these chimneys.

By these means the heat arising from the burning coal, instead of being confined in excess at the top of the oven, or being wasted by

escaping thence out of the oven, will be carried down into the two horizontal flues in the sides of the oven and under the floor, when it will be applied to the lowest stratum of coal, so as effectually to coke that portion of the charge, as well as to aid in the transmission of heat more equally from the whole surface to the centre of the charge.

For the better regulation of the heat of the oven and under the floor during the process of coking, by permitting the escape of a portion of the heat, should it at any time become excessive, the horizontal flues are made to open into the external air by flues and openings at the end of the oven in which the vertical flues are placed. Three of which openings of the same sectional dimensions as the rest of the horizontal flues under the floor are sufficient for an oven of the dimensions described, and in the position shown at G, G, G, in figs. 2 and 4, being, of course, fitted with proper doors, of suitable materials, for the purpose of confining the heat or allowing it to escape, when necessary.

The inventor does not claim to himself any particular shape, or size, or number, of horizontal flues, at the sides and under the floor of the oven, or any particular number or position in the oven of the vertical flues, and does not claim any particular size, or shape, or mode of building, or of working, coke ovens, but simply the construction of vertical and horizontal flues in the sides and under the floors of coke ovens, for the purpose of applying the heat of such ovens, in the manner above described, more efficiently to the charge of coal to be coked, and more directly to the lower portion and the under surface thereof, which is next to and upon the floor of the oven, than has hitherto been practised.

The *anchor oven*, by which the entire charge of coke can be drawn at once, previous to cooling, thus saving a considerable part of the labour in drawing the coke, and, also, the great destruction of bricks, which occurs to the linings, or interior bricks, by the application of water in cooling the coke in the ordinary method, I have already alluded to (see page 120, vol. VIII.) I am now enabled to give a plan showing the same, for which I am indebted to Mr. Berkley (see plates III., IV., and V.)

A, A, A, &c., are the ovens, the mouth of which is of the entire width of the oven, and of the height *a*, *b*; the dotted line *b*, *c*, being the height to which the oven is filled with coals; *d*, *e*, *f*, is the anchor, which is made of wrought iron, and which is placed in the oven when the coals are put into it, and which is, of course, imbedded in the coke.

When the oven is required to be drawn, a chain, *d*, *g*, *k*, is attached to it, which, passing over the pulley, *g*, leads to a winch at *k*, *h*. Power being applied to the winch, the whole mass of coke is drawn out of the

oven entire, and without breakage, and is cooled at the outside of the oven by water. In some cases an iron cover is put over the coke, which nearly excludes the atmospheric air, to such an extent as that its action has no injurious effect in wasting the coke. There is an apparent objection to this mode of drawing the coke, by the great size of the mouth of the oven, which has to be closed in the usual manner while the process is going on, but this, in practice, is found not to be difficult. The wear and tear of the anchor is also an apparent objection, but experience shows that the waste of the iron is really not great.

DESCRIPTION OF A COKE OVEN DESIGNED BY MR. BENJAMIN THOMPSON.

December 11*th*, 1845.

This oven was twenty-five feet long by ten feet wide inside, having a door (two feet nine inches) at each end, which was walled, and plastered up air-tight, when charged in the usual manner, with clay. Its chief peculiarities were—

1st. The admission of air, for the combustion of the volatile constituents of the coal, by openings which passed along flues in the division walls of the ovens, entering by vents on each side. The quantity of air admitted was regulated by plugs at each opposite end. The area (collectively) of the air passages was 6in. × 2in. × 4in. This, Mr. Thompson stated, would probably be found more than sufficient, but, if necessary, a small quantity might be admitted at each doorway, and that it was probable that this mode of admitting the air would promote the uniformity of the combustion of the gases, and waste less of the fuel, than by the usual method of letting the atmospheric air in by the door only.

2nd. Underneath the floor of the oven, cooling air passages were made, for the purpose of extracting the bottom heat from the mass of coke when the process was over ("and the stewing or hardening process was in operation"). The mouths of the flues (previously stopped up) were opened, and cool air permitted to wind through the passage, the effects being that the bottom portion of the coke was equally dense and bright with the general body.

The exit of this cooling air was provided for by a metal chimney, which came up from the level of the floor, twelve feet in length, twelve inches by three and a half inches inside, and half an inch thick, with an elbow at the bottom one foot in length.

Flues under the bottom, for cooling purposes, had previously been

patented by Mr. Jabez Church (see notice of his patent); and side air flues, for combustion of the gases, have formed the basis of several patents (amongst others, see a specification referred to at page 118, June, 1860), but I am not aware that any have been practically successful.

ON THE DESULPHURIZATION OF COKE; CLARIDGE AND ROPER'S PATENT.*—DESCRIPTION OF THE PROCESS.

The objects sought to be obtained by this class of ovens consist in the application of the waste gases of blast furnaces, or other unutilised combustible gases, for the purpose of causing the coking or carbonization of coal in coke ovens, either alone or as an auxiliary to the ordinary process of coking, and in the use of steam for the purpose of desulphurizing coke.

To effect these objects the coke oven employed is furnished with a false perforated bottom, placed a short distance above the true one, to receive the charges of coal to be operated upon. Under the false bottom a current of any unutilised combustible gases is admitted after the oven has been charged in the usual way, sufficient air being allowed to enter to insure the combustion of the gas. The heat so produced will cause or assist the coking of the coal contained in the oven, the heat being diffused as uniformly as possible under the false bottom by means of partitions deflecting the direct course of the flame, or by any other simple means. It is, of course, necessary to have a stack in connection with the flame space under the oven, and by means of a damper on this stack the heat of the oven may, in a great measure, be regulated. The combustible gases may also, if desired, be applied at the top or sides of the oven, with suitable modifications, and the flame spaces, whether at top, bottom, or sides, need not of necessity be separated from the internal contents of the oven by perforated partitions, the perforations being more for the application of steam than the waste gases. When the conversion of the coal into coke is effected, which is indicated roughly by the disappearance of heavy yellowish red flame in the oven, and while the coke is still at its maximum degree of heat, the supply of inflammable gases is cut off, and a current of steam admitted under the false perforated bottom, its escape to the stack being checked as much as possible. Or the steam may be applied from the commencement of the operation of coking, and, in that case, if it is desired to use the waste gases, they must be applied at the top or sides of the oven.

When very sulphureous coals are operated upon, it is advantageous to

* See Pamphlet on the Desulphurization of Coke by R. S. Roper, Esq., F.C.S. & G.S.

provide for the combined use of the waste gases and the steam at the same time, so that the steam may be applied for a longer period.

The steam passed under the false bottom is forced through the perforations into the coke oven, where it is retained under pressure, as much as possible, by closing all apertures from the oven, so that the coke may be thoroughly permeated by the steam, which, being decomposed by the sulphide of iron, or other sulphide present, the hydrogen combines with the sulphur of the sulphide, carrying it off in the gaseous state. In the case of extremely sulphury coals, the use of superheated steam is recommended, so that the decomposing action may be exerted for the longest period. It is evident that the steam required for desulphurizing the coke may be raised by means of the waste heat of the coke ovens themselves, and, also, when necessary, arrangements might easily be made for superheating the steam by the same heat, so that in fact the expense of desulphurizing coke in the way pointed out resolved itself simply into a question of first cost, and a small item for wear and tear. The coke after steaming sufficiently may be cooled in the usual way; but by continuing the use of steam the coke may be extinguished, and being then in an anhydrous state, or nearly so, is peculiarly adapted for particular purposes.

Description of plan.—The plan, plate VI., shows the nature of the coke oven employed for desulphurizing ordinary qualities of coal. It should, however, be observed, that the characteristic portion of this oven is the bottom, the other portions being as usually arranged in South Wales. The perforated bricks for the bottom are shown in plan and section on an enlarged scale, the form of the bottom being indicated in the plan and section of the oven.

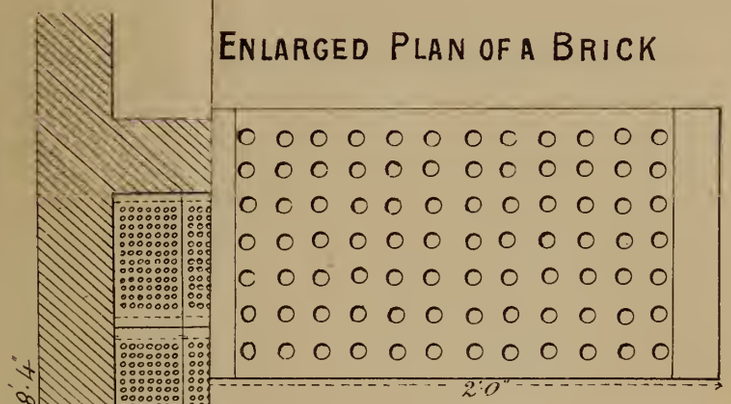
The steam enters by three branch pipes through the back wall of the oven, and under the perforated bottom, which is supported by two longitudinal brick partitions, with considerable transverse openings for the equal diffusion of the steam.

The damper in the stack is closed as soon as the steam is turned on, and thus prevents its escape in a great measure. The dimensions of the holes in the perforated bricks are found in practice to answer well, and should not be widely departed from. The conical shape of the holes is to prevent their obstruction by small pieces of coke.

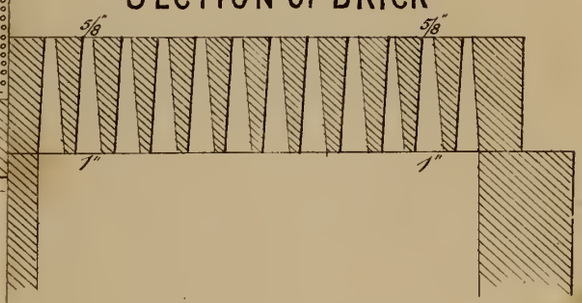
It should also be noticed that the dimensions of the steam pipes are those used for steam of about 8lbs. pressure, conveyed about forty yards from the boiler, and are, therefore, only suitable in similar circumstances; for high pressure steam much smaller pipes might be used.

EN.

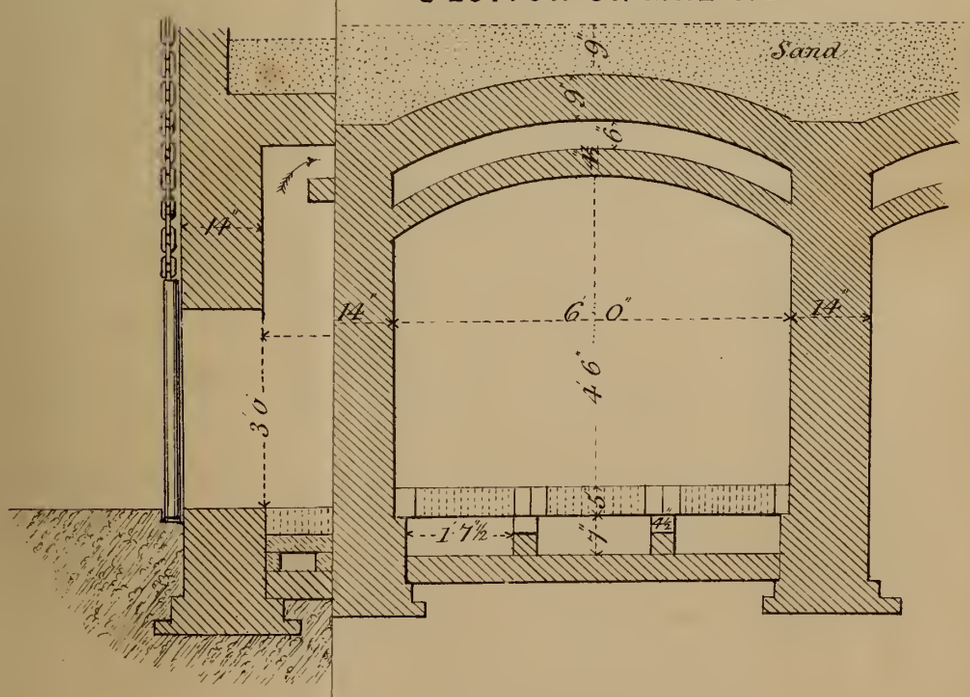
ENLARGED PLAN OF A BRICK



SECTION OF BRICK



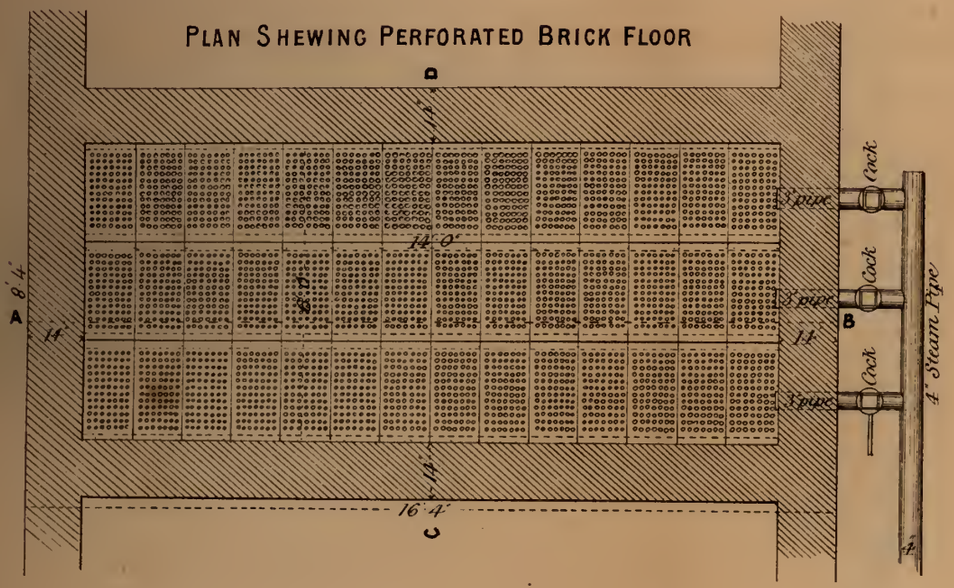
SECTION ON LINE C.D.



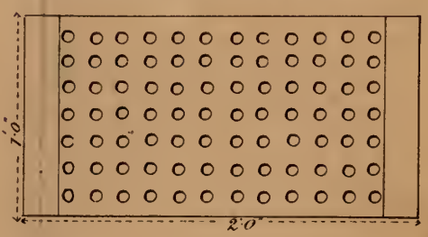
Lithographed by A. Reid, Newcastle.

ROPER & CLARIDGE'S PATENT COKE OVEN.

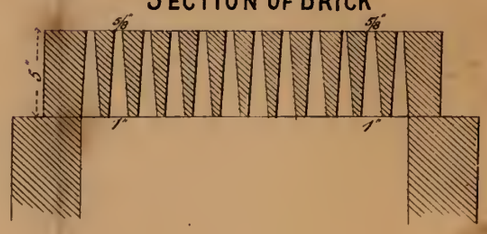
PLAN SHEWING PERFORATED BRICK FLOOR



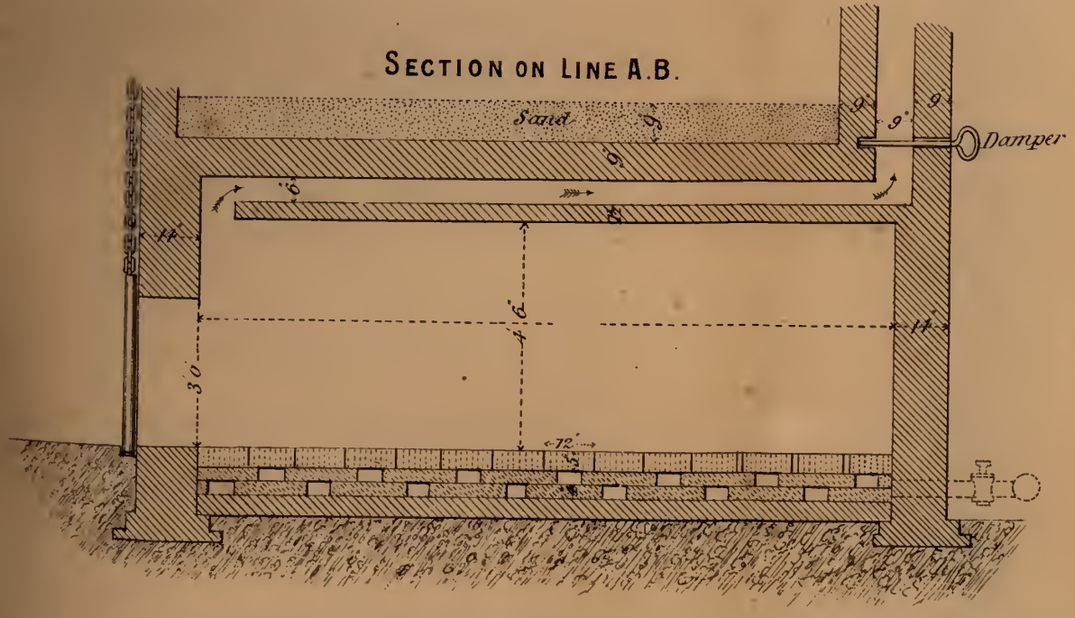
ENLARGED PLAN OF A BRICK



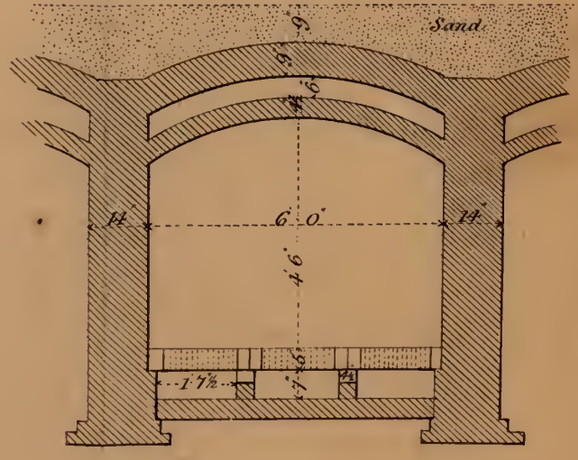
SECTION OF BRICK



SECTION ON LINE A.B.



SECTION ON LINE C.D.



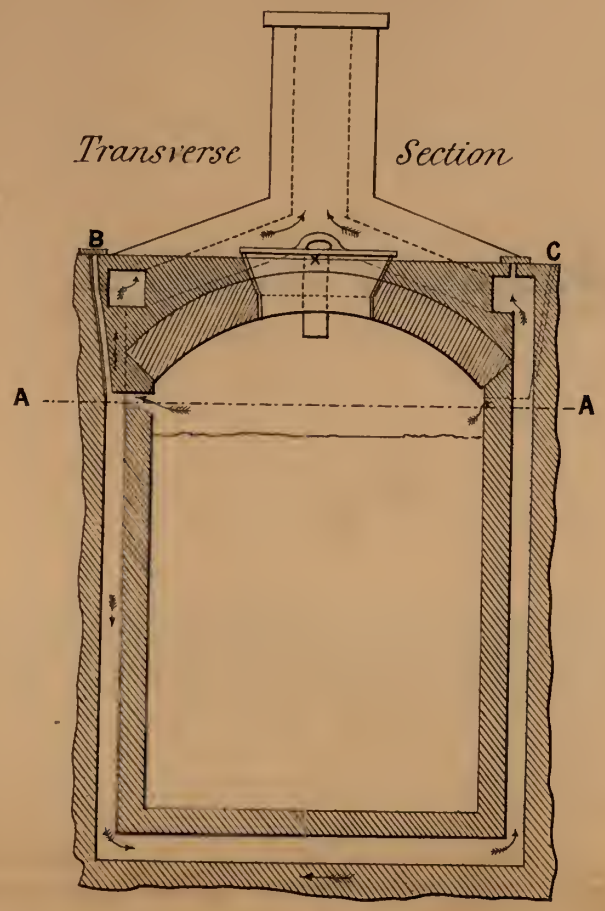
Proceedings No of E. I of E. 1860 1.

Lithographed by A. Reid, Newcastle.

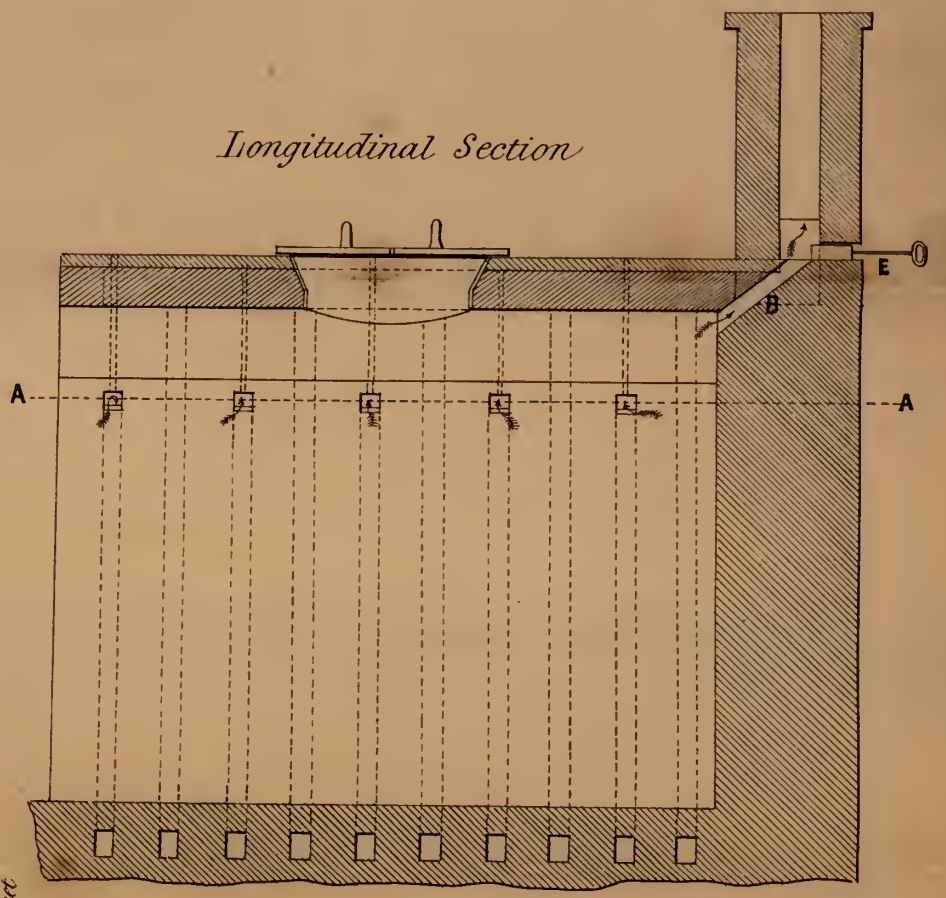
PLATE VII.

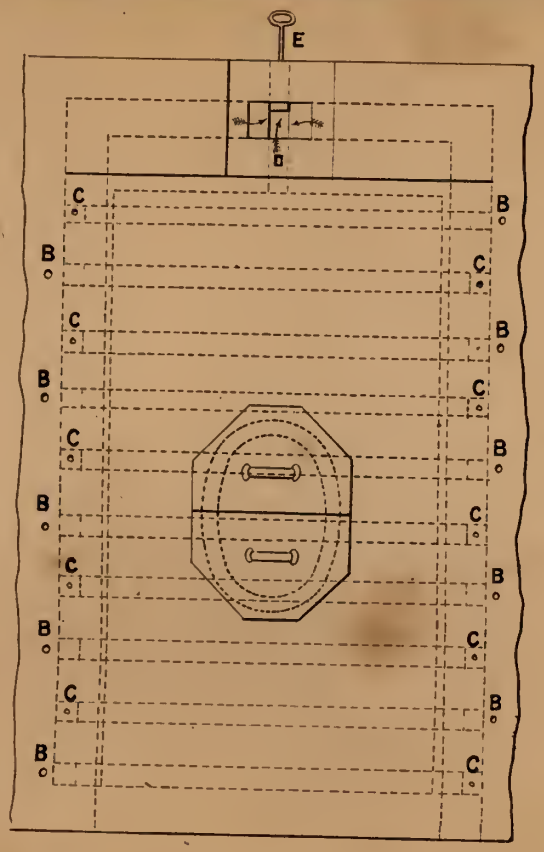
MACKWORTH'S PATENT RAILWAY COKE OVEN.

Transverse Section



Longitudinal Section





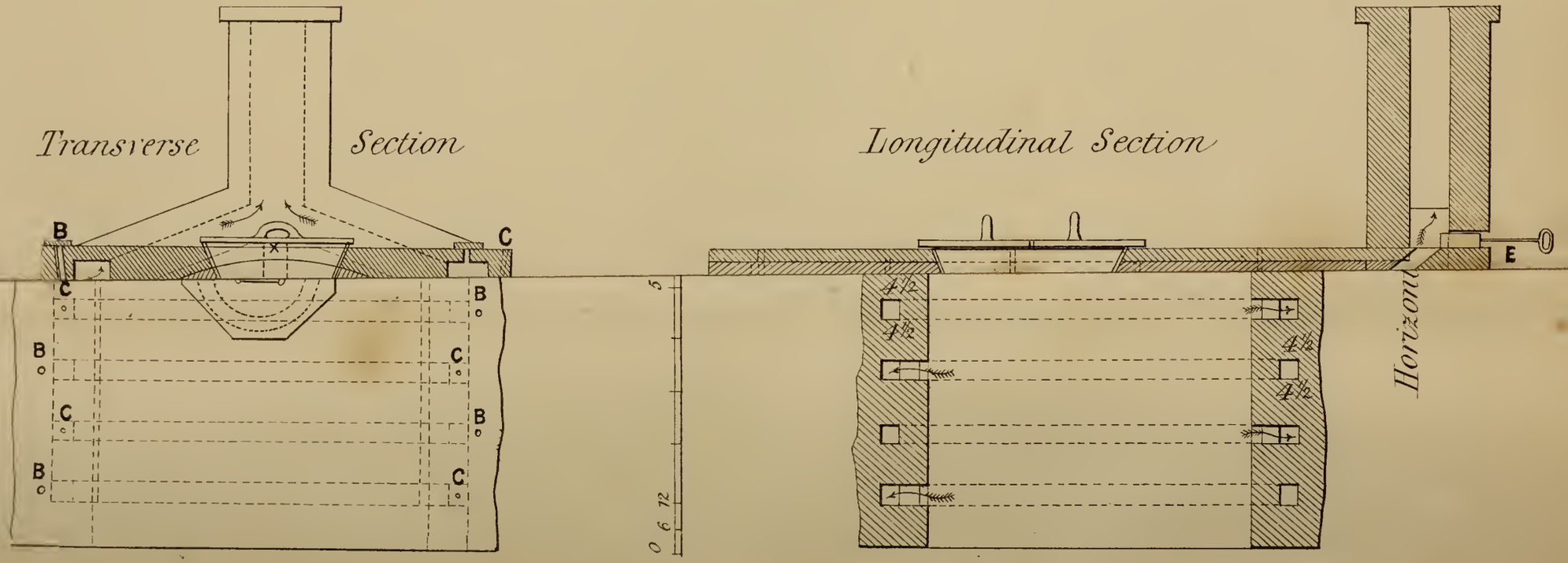
PLAN

Scale

Horizontal Section through A.A.

PLATE VII.

MACKWORTH'S PATENT
RAILWAY COKE OVEN.



Where a series of ovens are employed on this plan, it will be evident that the best arrangement will be to place a steam boiler in connection with the flues from the ovens, and thus raise steam by the waste heat of the gases produced by coking, in which case the cost of the process resolves itself into the interest on the prime cost of the boiler and fittings, together with the necessary alterations in the ovens, and small items for wear and tear and attention. With such an arrangement of boiler, and with coal of average quality, as used in South Wales, the entire cost of the process will not exceed threepence per ton, including license fees, and interest on capital at £5 per cent. per annum.

This process has already been applied to the following uses :—

The first trial of this process, for the desulphurization of coke, was made on the Meadow Vein coal at Pontypool. This coal has been proved to be useless for the cupola or blast furnace, from the large quantity of sulphur it contained—about 2·4 per cent.

After the application of steam by the above process, it was found to be equal to the best coke made at Pontypool for smelting iron, the iron retaining its greyness, and being as soft as could possibly be desired. The Rock Vein coke has also been desulphurized with most satisfactory results, yielding a bright silvery coke that could scarcely be surpassed.

Mineral charcoal, or soft coke, as it is more commonly termed, has also been operated upon in the same way, and it was found that tin plates made with this fuel were equal to charcoal plates, and better than those made from mineral charcoal made from Ebbw Vale Three-Quarter coal in the ordinary way, which contains only about ·5 of sulphur, whilst the coal from which the desulphurized mineral charcoal was made contained 1·64 per cent. of sulphur. This process has also been applied for many other purposes, with equally good results.

In *Mackworth's Patent Oven,* plate VII., the gases pass off in the direction of the arrows, through narrow flues, which present, in the aggregate a large heating surface, and distribute the heat uniformly. When the coal gives off smoke, air can be allowed to enter the pipes B, B, to burn the gas in the flues. The holes C, C, allow of each of the chimneys being examined, to see if they are working uniformly. The air required to support combustion is admitted through or near to the arch, in order that a stratum of gas may be interposed between the air and the coke, so as to prevent the burning of the latter. When the coal is well lighted, the flue D is closed by the brick damper, E. Before a charge of coke is drawn the top of the chimney must be closed by a damper to prevent the draught of cold air into the flues.

The advantages obtained by this oven are stated to be:—

1st. Economy of heat. The heated gases being made to pass round and heat three or even four sides of the oven before escaping, and the operation of coking is conducted at a lower temperature.

2nd. The entrance of air and exit of gases being diffused through more openings, the surface of the coke is less consumed, and the heat being rapidly conducted, and rendered uniform round the oven, double the depth and four times the usual charge of coal, can be operated upon.

3rd. The density, yield, and strength of the coke are said to be increased. The ovens may be constructed to hold twelve tons of coal or more.

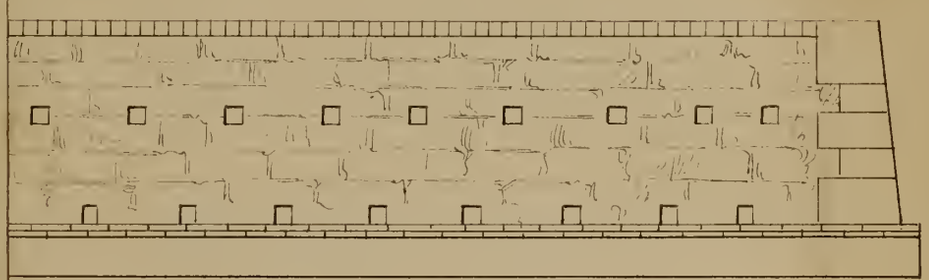
Rogers and Mackworth's Patent Coke Kilns, plate VIII., are simple in their construction, a sound concrete bottom, about eighteen inches in thickness, to guard against cracks or fissures, through which air from the outside might obtain access, is one essential point to be provided for.

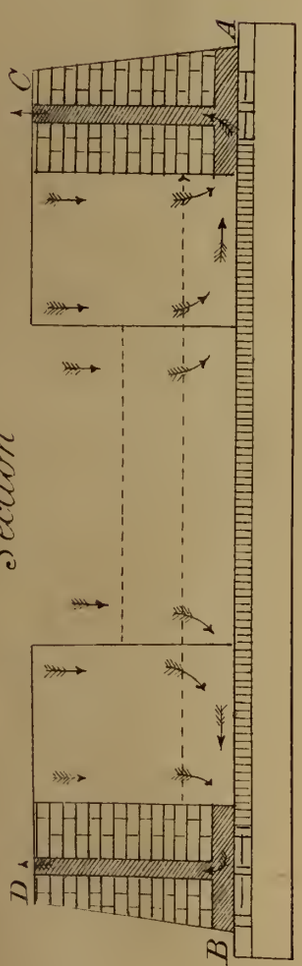
The external walls and flues may be all constructed of rubble stone, or common brick, the inside walls and floor require to be faced with common fire brick, but not the flues; the entrance at each end is built up with bricks laid in mortar.

The process consists in having flues constructed carefully with large blocks of coal across the interior of the kiln, providing a clear passage for the air and gases between the corresponding flues in the opposite walls. If the coal varies in size, it is an advantage to lay the largest coal at the bottom, diminishing in size towards the top. A fifty-ton kiln may be filled to a depth of four feet six inches, or upwards, above the top of the cross flues, finishing off with a layer of dead ashes, two or three inches in thickness, forming the surface or cover of the kiln on the top.

When the kiln is charged, fire is applied at the flues marked A in the section, and the flues B and C are stopped, the draught then being from A to D, through the cross flues In six to twelve hours the flues B on the opposite side of the kiln may be fired, stopping the flues A, D, and opening the flues B, C. As soon as that side of the kiln has become ignited the draught may then be reversed backwards and forwards for a short time until the vertical flues C, D, have become thoroughly red hot; all the horizontal or cross flues A, B, must then be closed, and all the vertical flues C, D, opened. A powerful heat having been created by the heated state of the vertical flues, C, D, the atmospheric air is now drawn down through the top of the kiln, passing through the interstices of the coal to the seat of combustion beneath, whilst the products of combustion are passed off through the vertical flues C, D.

COKE KILNS.





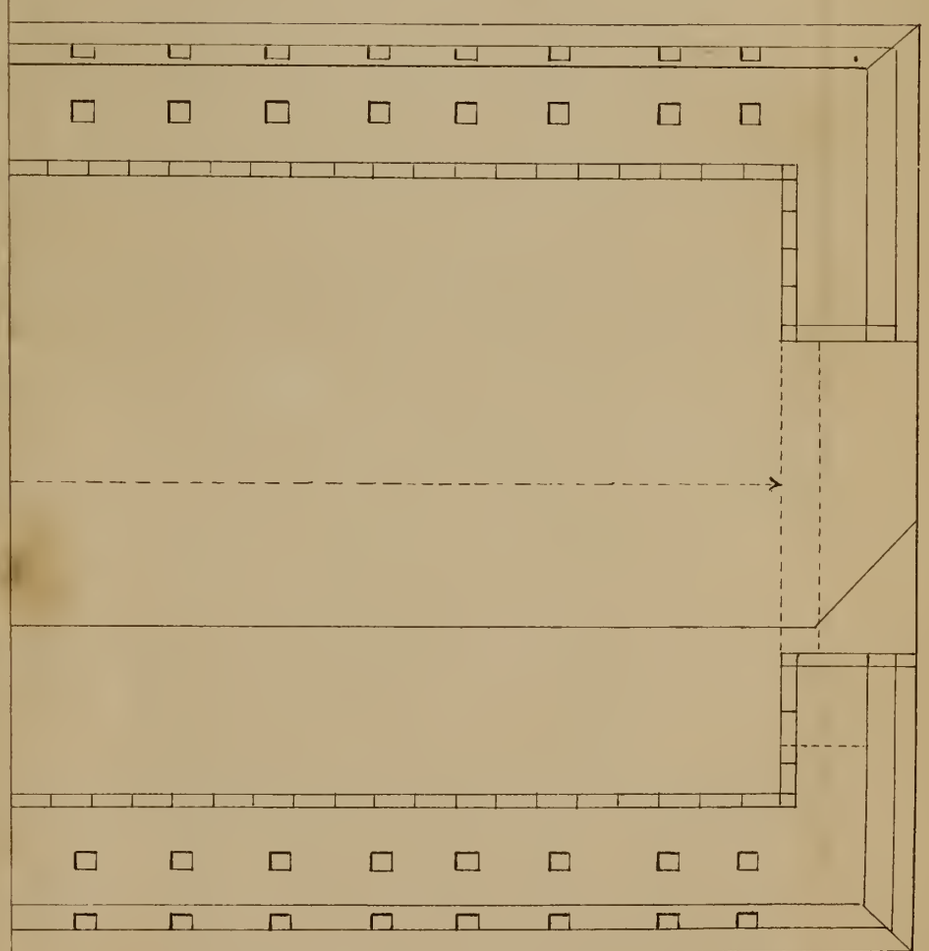


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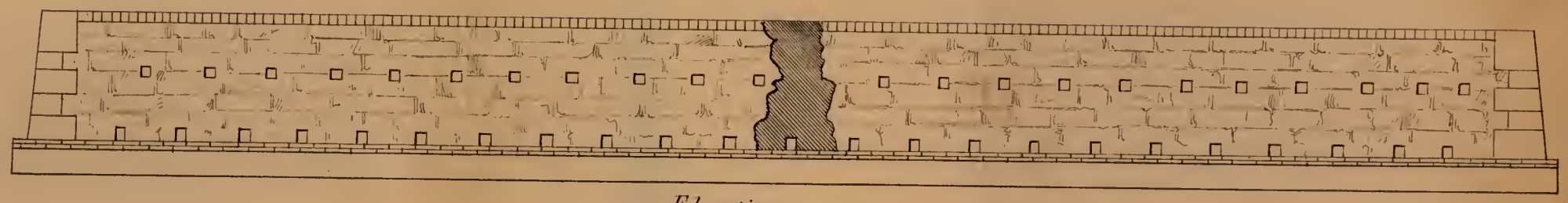
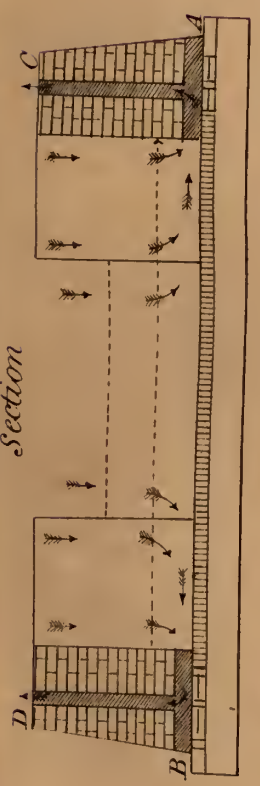
PLATE VIII.

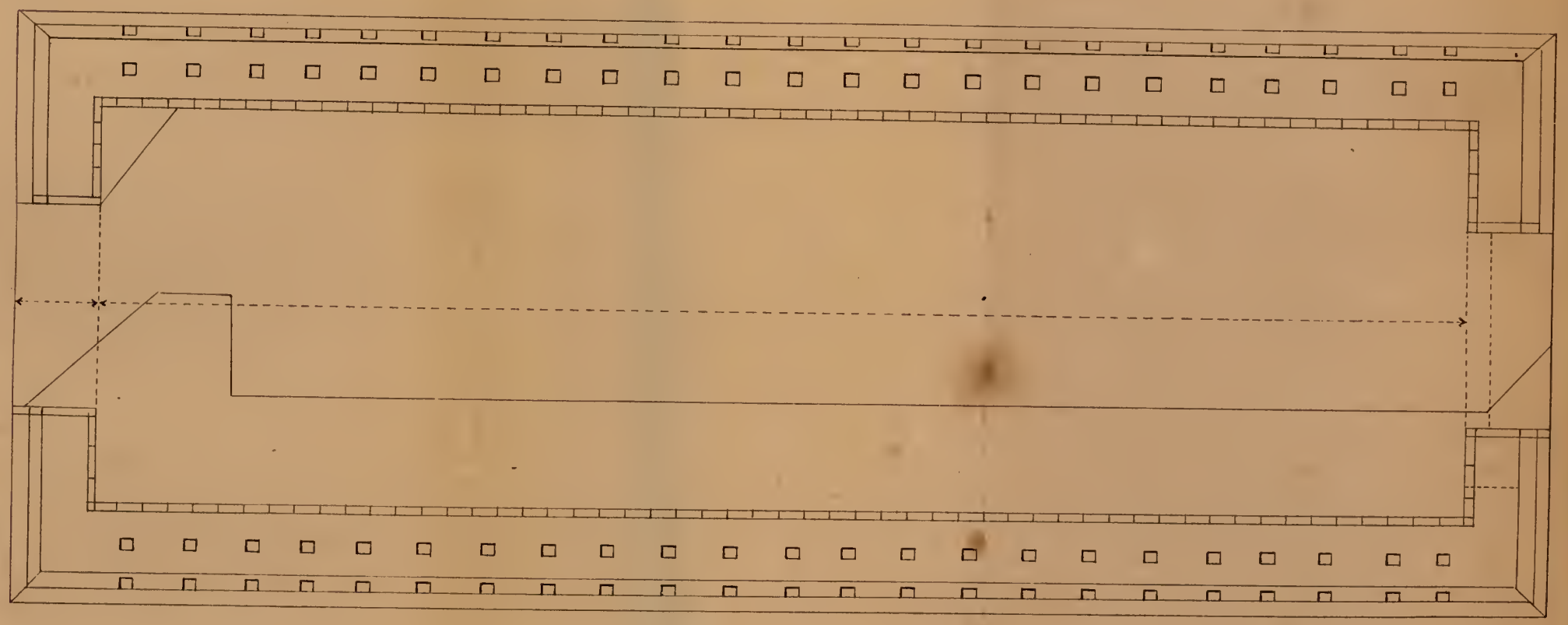
ROGERS & MACKWORTH'S PATENT COKE KILNS.



Elevation



Section



Plan

(Proceedings N° of E.I of E. 1860-1.)

Lithographed by T.A.Kell Newcastle

FIG 1.

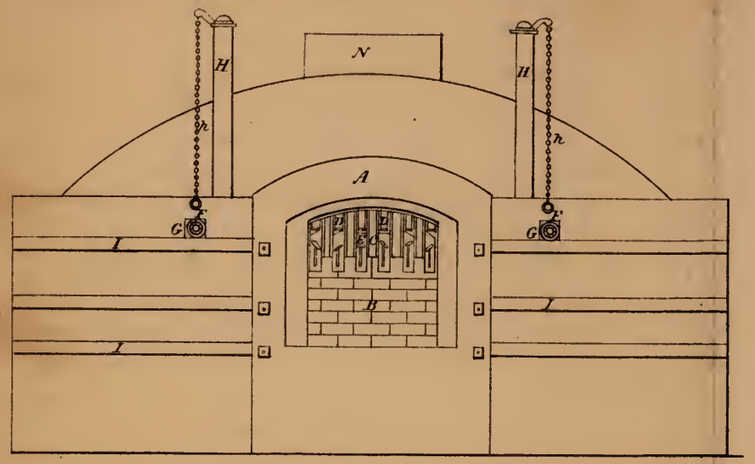


FIG. 2

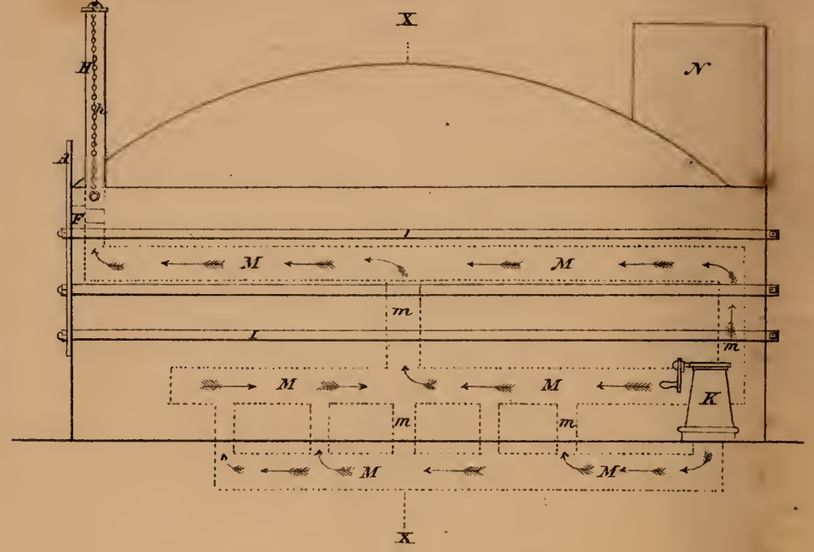


FIG. 3.

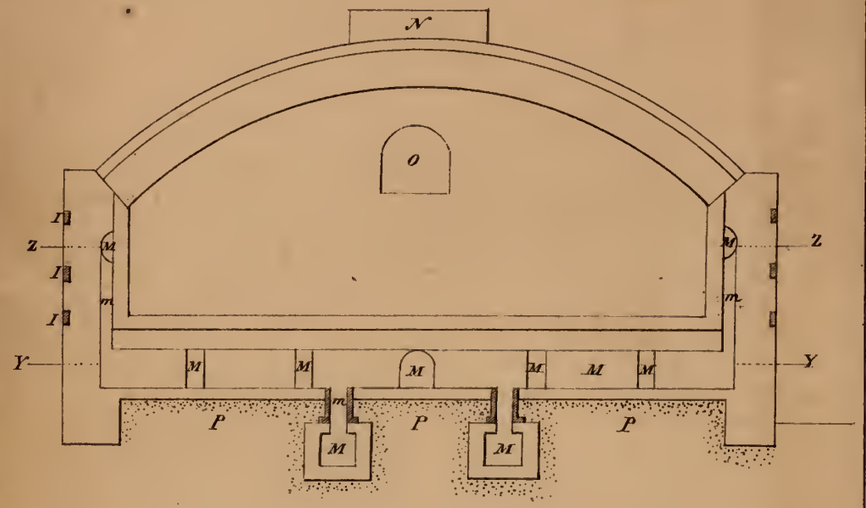


FIG. 4.

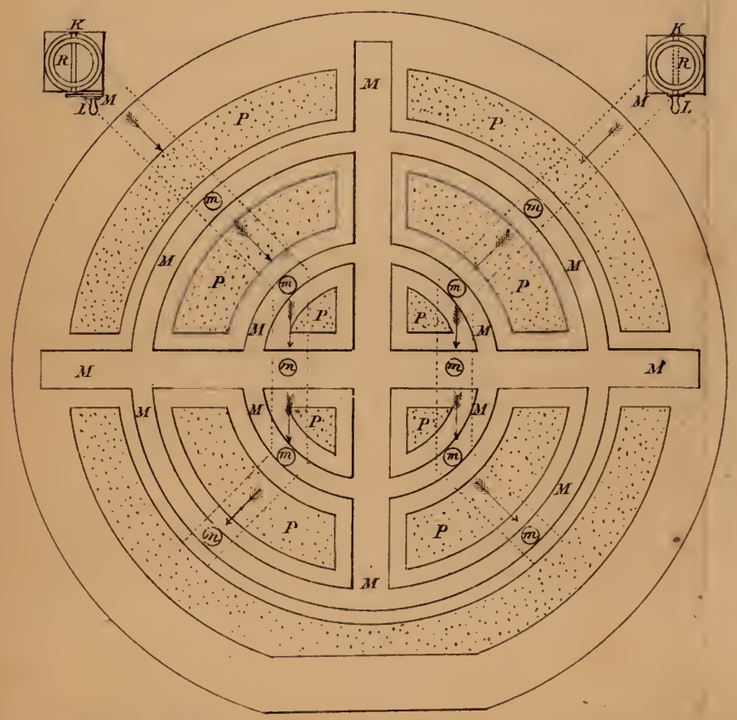


FIG. 5

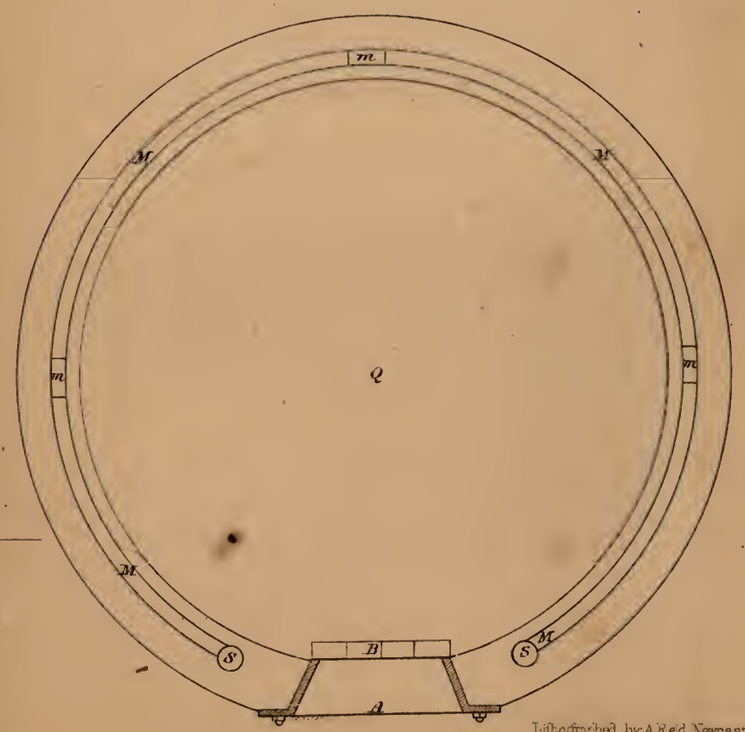
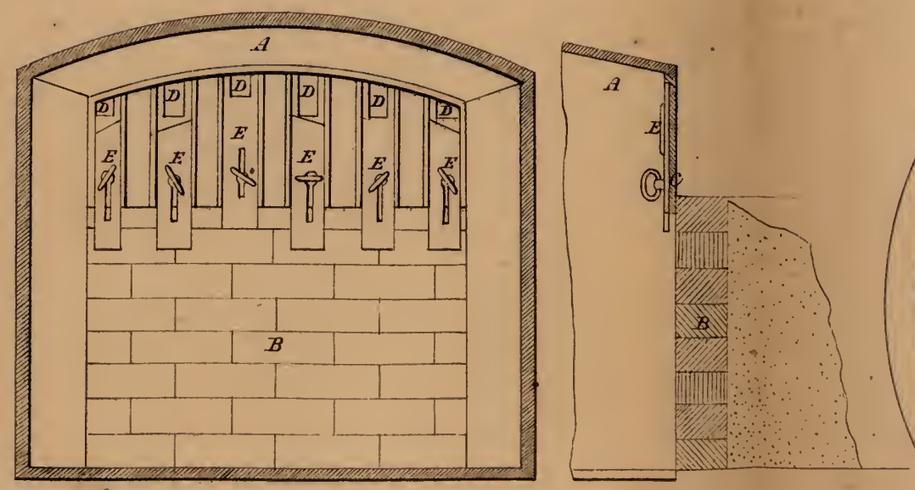


FIG. 6.



Lithographed by A. Reid, Newcastle.

FIG 1.

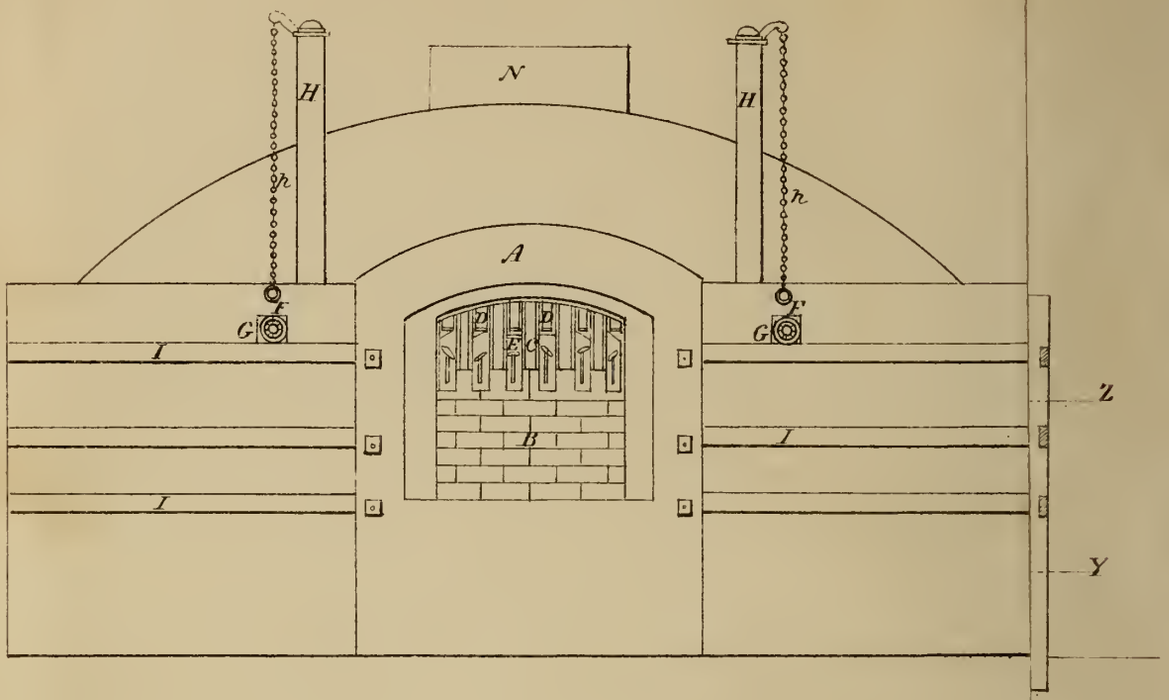
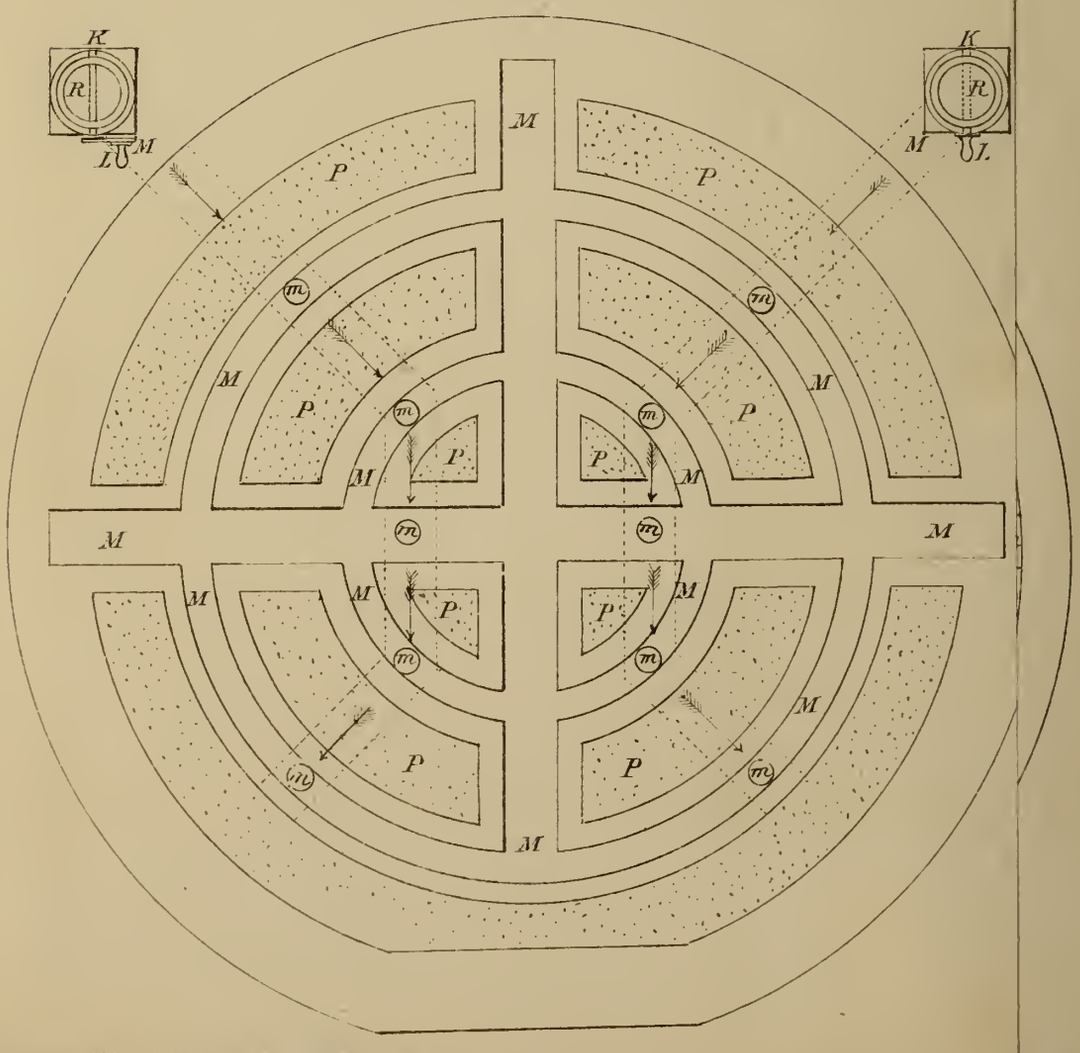


FIG. 4.



The coking process gradually ascends from the bottom of the kiln to the top. The exact state of the process being ascertained by thrusting an iron bar downwards, at different parts of the surface, until it is stopped by the hard mass of coke beneath; if found to be proceeding irregularly at any part, it may be regulated by closing all or part of the vertical flues on either side.

In a *fifty-ton kiln* the process occupies seven to eight days, but for locomotive purposes ten days are requisite.

This process, by which coal is coked, being effected by combustion from beneath, is the reverse of that obtained in ordinary coke ovens by radiated heat, combustion progressing downwards. After the vertical flues have become thoroughly red hot, and all the horizontal flues, A, B, are closed, combustion is supplied with air through the open top of the kiln, and as the air reaches the melted coal flame is produced, and the bituminous vapours, with the hydro-carbon gases, descend through the incandescent mass. If the flame emitted from the top of these flues loses its pale blue color and acquires illuminating power, thus indicating that bi-carburetted hydrogen is being passed off, the too rapid combustion is at once checked by temporarily closing those flues which emit the illuminating flame.

During this process no smoke or flame is emitted from the top or surface of the kiln, which is perfectly cool when the coking of the whole mass is completed, which enables a man to walk upon the top of the kiln to test its progress.

The saving, in working expences, is stated to be fifty per cent, the yield fully seventy-five per cent., with a greater density and more uniform quality than is usually produced.

*Church's Improvements** in the manufacture of coke and construction of coke ovens are—

1stly. For regulating the supply of air to the ovens, during the manufacture, by means of regulators and valves.

2ndly. The cooling of the coke within the ovens, and before the removal thereof, without exposing it to the air; and

3rdly. The application of *electricity* to the purifying of coke from sulphur and other metallic admixtures.

Fig. 1, plate IX., represents a front elevation, and fig. 2 a side elevation.

Fig. 3 is a transverse section on the line X, X, fig. 2.

* See specification of Jabez Church, for Manufacture of Coke and Construction of Coke Ovens, 1845.

Fig. 4 is a plan on the line Y, Y, fig. 3; and

Fig. 5 is a plan on the line Z, Z, fig. 3.

Fig. 6 is an elevation, and fig. 7 a section of the principal parts of the oven front, on a larger scale than in the other figures. A is the mouthpiece, and Q, fig. 3, the floor; B a temporary wall of brickwork; C is a cast-iron door, called the "regulator," in which are a number of oblong apertures, D, D, for the admission of air to the interior; E, E, are vertical slides, by which D, D, all or any of them, may be closed wholly or partially; F, F, are two additional air passages made in the side walls, and carried in an upwardly inclined direction towards the interior of the oven, so that the air supplied through them may not impinge directly on the surface of the coal; G, G, are circular slide valves, by which the passages F, F, are opened or shut as required; I, I, are iron bands encircling the exterior of the oven, to strengthen the same; N is the chimney, and O the flue leading into it from the interior of the oven; K, K, are openings through which, after the coal has been carbonized, cold air is introduced for cooling down the coke; and R, R^1 (fig. 4), are two valves commanded by handles, L, L, by which these passages are opened or closed, being represented in the one case as closed, and the other as open; M, M, M, are horizontal passages carried underneath and around the oven (but not communicating with the interior), through which the cold air circulates, after its admission through the openings K, K; and *m*, *m*, are smaller vertical passages, by which the main passages, M, M, communicate one with the other; H, H, are vertical pipes, with hinged caps or covers, which are opened, when required, by the dependent chains, *h*, *h*, to allow of the escape into the atmosphere of the air employed in the cooling process—[S, S, in fig. 5, represent the bases of these tubes]; P, P (fig. 4), are parts filled up with concrete.

The oven is loaded as usual. As soon as the main body of coal has become fairly ignited, the regulator, C, is closed; its edges and the joints of the temporary brickwork are well luted; the passages D, D, and F, F, are, in the first instance, left entirely open (M and *m* being closed). As the coking of the coal advances, D, D, and F, F, are gradually closed, until, at the conclusion of the process, they are wholly shut.

The valves R, R^1, are then opened for the admission of air to cool down the coke, and the caps of the exit pipes H, H, pulled off—the coke not being removed from the oven until it has been thoroughly cooled.

When desirable to have a coke more than usually free from sulphur, &c., the coal, at the completion of the process of carbonization, is sub-

jected to a current of electricity, thus—The apertures D, D, and F, F, being closed as before-mentioned, an iron rod is introduced through the temporary brickwork in front into the coke near the bottom and through the back of the oven, just under the chimney flue O; a second rod over the surface of the coke, so as to rest upon and be in contact therewith. The former rod is connected with the positive pole of a powerful electric battery, and the latter with the negative pole, each by means of a stout copper wire, leaving the body of coke to complete the circuit. With a mass of coke amounting to about six tons, it is stated that the time it may be beneficially subjected to the electric action is about two hours, and that, from repeated analysis of equal portions of coke, one of which had been subjected to the electric action and the other not, the former was freer from sulphur and other metallic admixtures, in the proportion of twelve to one.

I am indebted to Mr. John T. Ramsay for having brought this patent, and other information, under my notice.

DISCUSSION RESUMED.

The PRESIDENT—I have received a letter from Mr. Stobart stating that he is at issue with Mr. Steavenson as to the substitution of flued for open ovens.

Mr. STEAVENSON—In the case of flued ovens I examined them carefully. I gave two per cent. in favour of the flued ovens. The per centage is given by me in the first appendix.

The PRESIDENT—Mr. Stobart will, I presume, furnish us with his experiments?

Mr. STEAVENSON—I will state the reason why I prefer flued ovens. They give an increase of regulating power, and protect the coke from the effects of stormy weather.

Mr. MARLEY—The results are actual experiments, ten in one instance and twenty-one in the other? You take them for what they are worth?

Mr. STEAVENSON—The open ovens extend over five years, the flued ovens perhaps twelve months. What I have further to describe is entirely with respect to patent ovens. No. 1 is by Breckon and Dixon.

Mr. BERKLEY—The Marley Hill Coking Company had an oven made at Gateshead similar to these twelve years ago. The gas was carried under the flues. It was not found to answer, and was, therefore, abandoned.

The PRESIDENT—I can speak with confidence as to the experiments of the Marley Hill Company with the ovens at Gateshead twelve years ago. They had one of large size—an experimental oven—in which the heated air was conveyed underneath the floor of the oven, probably not in the precise way as in the patent ovens, but still the object was to convey the heated air from the top, and to convey it into flues spreading underneath the floor of the oven. We had a tall chimney, and there was plenty of draught. The result of this was, as you very properly state, a failure. The coke was quicker made—a third of the time was perhaps saved. It was so, at least, in these experiments. But it was found that the coke was not of such good quality as in the ordinary ovens. The upper and lower parts of the coke were pretty good, but the middle was not properly coked. It was not equal to the coke which remained the usual time in the common oven. I should, therefore,

like to know what were the results of these patent ovens with reference to the quality of the coke as a mass. I understand there are several of them erected at Mickley. These have been in operation some time, and it is desirable to know the difference between them and the ordinary ovens.

Mr. Steavenson—I have seen the reports, which are very satisfactory. I believe it was coked through the entire mass of coal.

Mr. Marley—It was perfectly coked in the middle. There was a parting where the two heats had met.

The President—You believe that the coke was equally good in the middle with that of the top and bottom?

Mr. Marley—I cannot speak positively, but I have no doubt it was. I offered to introduce Mr. Breckon as a friend to this meeting: he is not a member.

The President—Mr. Breckon might communicate, through you, the practical result. You said there was 15 per cent. more produce. That is very important, looking at the thousands of tons made weekly. If the coke is not quite so good, there is a great deal used for iron furnaces, and it may be as useful as sufficiently good coke for that purpose.

Mr. Marley—They represent that it is better than the coke made in the ordinary ovens, and at the present time they are receiving a higher price for that coke than the other, for foundry purposes.

Mr. Steavenson—It is coked at a very high heat, which is favourable for producing a good article.

The President—Did you give us the comparative cost?

Mr. Steavenson—I have not the cost of erecting that oven. The cost would be greater, on account of the number of flues. The great difficulty is to keep the flues open. They do not stand well, on account of the intense heat.

The President—The Marley Hill Coking Company could have no objection, I presume, to give us the cost of working their ovens. Mr. Liddell, under whose management the Mickley ovens are, would know the cost of these ovens, and perhaps he would furnish the information.

Mr. Steavenson—I can get the cost of erection from the patentees.

Mr. Berkley—Is the cost a matter for this Institute to go into?

Mr. Marley—If you produce fifteen per cent. more in a third less time, and get one shilling per ton more in price, the cost of making the

coke becomes an important question. I have no authority to speak on behalf of Mr. Breckon. Will you allow him a voice, if introduced?

The PRESIDENT—Can you not put it down in writing? You could bring it here with your remarks upon it.

Mr. STEAVENSON—I had the cost from Mr. Liddell privately, but I do not consider myself at liberty to use it. Here are plans of the anchor oven, by which three or more charges can be drawn at once.

Mr. SPENCER—I saw one of these anchor ovens working in 1857 in Lancashire.

The PRESIDENT—Has this been in operation in any other locality?

Mr. STEAVENSON—Yes. I will instance two or three cases. The first is Pontypool.

Mr. GREEN—I have an oven with a false bottom. The coke is quite black, however, when made in that oven.

The PRESIDENT—In that case the object was to carry off the sulphur. My impression is it has not answered.

Mr. DUNN—The patent has been purchased by Francis Morton.

Mr. REID—Generally there has been a feeling of dissatisfaction with it.

Mr. MONRO—I have seen those in use at Walker Iron Works. They make very good coke, provided you are careful to use a proper kind of coal, but the proprietor sends the cokemaker so many kinds of coal. We only allow six days for coking, and they require seven or eight.

Mr. MARLEY—I do not think the coking in such ovens is carried on at a sufficient degree of heat to make it sufficiently hard or pure coke. It is too low a temperature during its whole process.

The PRESIDENT—That is my impression as to the double ovens. They did not get a sufficiently high temperature to carbonize the coal.

Mr. MARLEY—I think the President is mistaken in this as to Breckon's. He gets a very high temperature.

The PRESIDENT—Where have we experience of these ovens?

Mr. COCHRANE—They are used in the Forest of Dean. I do not know any results.

Mr. REID—There is a translation of it in M. Jars. You get the date when coking was first known in 1730. I think he states that at first they called the coke made in open ovens cinders, and in close ovens they called it coke.

[Mr. STEAVENSON then read that portion of his paper which alluded to Church's Improvements.]

Mr. Ramsay—It makes excellent coke, though not superior to others. It is not so handy to work. I have given it up.

Mr. Steavenson—They are more complicated than the others.

Mr. Ramsay—When Church's patent was taken out it was for the purpose of cooling the oven, now they cool it by throwing water in.

The President—They practically use the water?

Mr. Ramsay—Yes; but I think it of no advantage. Water does not improve the coke.

The President—Do you throw water inside your common ovens?

Mr. Ramsay—I am sorry to say we do.

Mr. Berkley—Many engineers pour water on the coke after it is taken out of the oven. You see them doing this in the coking for the locomotives. The great per centage of coke is generally from water.

Mr. Steavenson—The application of electricity to remove the sulphur is a peculiarity. Mr. Church applies electricity.

The President—How does the electricity act in removing the sulphur?

Mr. Steavenson—I do not think it likely to do so.

The President—I have seen Mr. Church's ovens in the south. I was informed that they had some effect on the sulphur, but could never make it out satisfactorily to myself.

Mr. Ramsay—My opinion is, that in coal where there is a great deal of sulphur, it is of use. I have seen the coke after it was burnt, and the sulphur was quite marked upon it. I have tried Church's electricity, and have found it an advantage in inferior coals.

Mr. Steavenson—There is a plan of coking by the bottom flues. It is a long oven, twenty-two feet long.

Mr. Ramsay—They have them in use at the Bellingham Iron Works.

Mr. Marley—One object is to keep the round coal from the side of your oven.

Mr. Ramsay—The appearance would be injured by using rough or unscreened coal.

Mr. Marley—The reason is, that however good in theory to keep the round coal from the side of the oven, it is not so good in practice. The better way is to break the coal.

MR. DUNN'S PAPER.

The next paper for discussion was that of Mr. Dunn, on "The Geology of the Cumberland District."

The PRESIDENT—As this is a very important subject, and as Mr. T. J. Taylor, who has paid great attention to the geology of that district, is not present, it might be well to adjourn the discussion. I expect that next month Mr. Boyd will be prepared with a paper on "The Coal in the Northern part of Northumberland," which paper will partly bear upon this subject; this is an additional reason why the discussion of Mr. Dunn's paper should be postponed.

The discussion was accordingly adjourned, and the meeting then broke up.

NORTH OF ENGLAND INSTITUTE
OF
MINING ENGINEERS.

GENERAL MEETING, THURSDAY, DECEMBER 6, 1861, IN THE ROOMS OF THE INSTITUTE, WESTGATE STREET, NEWCASTLE-UPON-TYNE.

NICHOLAS WOOD, ESQ., PRESIDENT OF THE INSTITUTE, IN THE CHAIR.

In the absence of the Secretary, the minutes were read by Mr. BERKLEY.

The PRESIDENT stated he had received a letter from Mr. Robert Hayes, solicitor to the executors of the late Mr. Robert Stephenson, in reply to the inquiry whether there was any specific instruction in the will of Mr. Stephenson as to the disposition of the money he had bequeathed to the Institute. The letter stated "that the will contained no specific instructions, further than that the money was left for the general purposes of the Institute." He (the President) might add, that the money had been placed in the bank at bank interest. A committee had been appointed to consider the best mode of disposing of it, but that committee had not yet reported, and it would, therefore, remain in the bank of Messrs. Lambton and Co. until the committee reported.

The next notice was that the meeting be made special, for the appointment of officers in case of vacancy. The subject now to be considered was, such an alteration of the ninth rule as would enable general meetings to elect officers in cases of vacancy.

Mr. MARLEY suggested that, in making the alteration, the following proviso should be added—"Notice of such election having been given at the previous general meeting."

The rule was then altered accordingly.

The PRESIDENT stated that a letter had been received from Mr. R. Von Carnall tendering a present of some books and maps to the Society, which it was agreed should be duly acknowledged. He also stated that he had written to Sir Roderick Murchison to ascertain if the Institute could be furnished with a set of the Ordnance maps and sections free of cost. Sir Roderick wrote him in reply that he was prohibited by the Government from giving away a single sheet. They could only be obtained through a Treasury order. The Council considered it was not likely that a copy could be had gratis, and they therefore recommended that a set should be ordered. The President stated that about ninety maps had been published, containing all the southern counties, and including one-half of England. He (the President) had inquired of Mr. Sandford, Charing Cross, London, who was one of the persons selected to sell them, as to the cost, and he found it would be about £46.

The next subject was with respect to the proposed meeting of the Institute in some of the midland counties. The Council had taken this into consideration, and they thought it desirable to have a meeting in one of the midland counties.

Mr. CRONE—Will it be necessary to confine it to the midland counties? It might be held in Scotland.

The PRESIDENT said, the sub-committee recommended by the Council would consider that question. It might be in any central town in the kingdom.

A sub-committee, consisting of the President, Mr. Taylor, Mr. Reid, and Mr. Daglish, was then appointed.

The PRESIDENT said, the next proceeding was the election of a Vice-President. It had been stated to him by some members that it appeared very desirable, in electing a Vice-President, that they should have some person from amongst their distant members—a gentleman of standing, character, and influence in the profession.

Scrutineers were then appointed, and the result of the voting was—For Mr. Woodhouse, of Derby, 16 votes; for Mr. Sopwith, of London, 3; and for Mr. Cossham, of Bristol, 1. Mr. Woodhouse was accordingly elected.

The PRESIDENT said, the circular convening the meeting informed the members that there were two subjects to be brought before them at this meeting, namely, the discussion on Mr. Dunn's paper, and the paper

to be read by Mr. Boyd. In the discussion on Mr. Dunn's paper, he (the President) begged to say a few words. Mr. Boyd's paper was on the geology of the northern part of Northumberland, and the coal seams of that locality. That would bear materially on the discussion of Mr. Dunn's paper. Mr. Boyd's paper would throw considerable light on the subject. Under these circumstances, it was a question for consideration whether the discussion of Mr. Dunn's paper had not better be deferred until they had Mr. Boyd's paper before them. Knowing a little of the general bearing of Mr. Dunn's paper, and having some years ago published a paper, with plans and sections, on the geology of Northumberland, and having read Mr. Boyd's paper, he was of opinion that the two papers would be much more effectively discussed together. He would, therefore, propose that the discussion of Mr. Dunn's be postponed until they had Mr. Boyd's before them.

Mr. Dunn said he was quite agreeable. He supposed there was a very great analogy between Mr. Boyd's paper and his own. He was going to put a question on another subject,—he was going to ask whether it was intended to discuss the Burradon question?

The President—Let us consider the question before us first.

The meeting having decided to postpone the discussion of Mr. Dunn's paper, Mr. Dunn repeated his question.

The President said, he could not answer the question. It depended on the Institute. It was in their hands. It was a very important question, and it had certainly not been discussed yet.

Mr. Dunn—As it stands, it is a very imperfect paper, and more particularly so as a great number of facts have come out since, bearing on the subject.

The President—You think, since the reading of the paper, a great many facts have come out bearing upon the subject. Are you in a position to furnish these facts?

Mr. Dunn—Yes; I have visited the locality since. There is a question raised by Mr. Taylor as to the cause of the accident.

The President—Where?

Mr. Dunn—At the termination of the paper. Read from "such is an abstract of the principal facts" to the end, "as may be decided upon." A great many facts have come out which were not raised before.

The President—Can you inform the Institute whether any legal proceedings have been taken against the owners?

Mr. Dunn—Legal opinions have been taken.

The PRESIDENT—It is extremely desirable that we should not mix up the Institute with any legal proceedings. It would fetter the discussion very much if members thought that any opinion expressed by them in such discussion would be made use of in a court of law, as the opinion of a professional person on the subject. Until we are quite satisfied that we are quite free from any legal or ulterior consequences, I think it would not be desirable to go into the discussion.

Mr. BERKLEY moved that the discussion on the Burradon Explosion be postponed *sine die*.

Mr. BOYD seconded the motion, which was put from the chair, and carried *nem. con.*

The PRESIDENT then said,—At the meeting in November I alluded to the lamented death of one of our Vice-Presidents, Joseph Locke, Esq., M.P. That gentleman having received his professional education in the coal mines in this neighbourhood, and having been associated with the Messrs. Stephenson in the early progress of railway engineering, and having ultimately become one of the most eminent members of the profession as a railway engineer, and being at the time of his death a Vice-President of this Institution, it appeared to me that it was due to the memory of such a person that some notice should be taken by me, as President of this Institution, of his labours in the profession, and of his connection with the Institute.

Mr. Locke was born at Attercliffe, near Sheffield, August 9, 1805, and was, consequently, 55 years of age when he died. His father removed to Barnsley when he was four years of age, and he received his education at the Grammar School there. On completing his education, he was placed under the late William Stobart, of Picktree (father of the present Col. Stobart, of Etherley), who at that time was one of the most eminent colliery viewers of the district, as an apprentice to that profession; and from Mr. Stobart he went to the late George Stephenson, as one of his "young men," as an engineer, and as such I first became acquainted with him; and I believe it was on a survey which he made for me at the late Lord Crewe's (then John Crewe, Esq.) collieries in Cheshire, that he earned the first money in his profession. With Mr. Stephenson he acquired a knowledge of engineering, and particularly with the construction of the early locomotive engines, as well as completing his knowledge of mining engineering. And it is a circumstance which merits notice that Mr. Locke, as well as Mr. Robert Stephenson, often

referred to the knowledge of mining engineering, which they received at Killingworth and elsewhere, as being of the most essential service to them in their profession of civil engineers, particularly in tunnelling; and it may likewise be stated, that it was in this description of work that the elder Stephenson more particularly employed Mr. Locke at Liverpool, in the construction of that railway.

I had, at the time Mr. Locke was with Mr. Stephenson at Newcastle, many opportunities of observing his habits in acquiring a knowledge of his profession, and it is only an act of justice to his memory to say, that as in after-life, in the duties of that profession, he was remarkable for his untiring industry, assiduity, activity, and intense application, his frame of body was of that stamp which enabled him to go through almost any amount of work; and his mental powers being of the same stamp, it is no wonder that he should have attained the rank and eminence in his profession which he held at the time of his death.

When Mr. George Stephenson was employed in surveying the line of the Liverpool and Manchester Railway, Mr. Locke was one of his assistants; and when Mr. Stephenson undertook the duties of chief engineer, Mr. Locke was employed by him as superintendent of the tunnelling, and some of the most important works at the Liverpool end of that railway, and he remained as superintendent until the opening of the line on the 14th of September, 1830. In the question of the motive power to be employed, Locke adopted, like his master, the locomotive, in preference to fixed engines; and the practical experience which he had derived at Newcastle of the construction and minutiæ of these engines, rendered him a useful auxiliary to Mr. Stephenson. In the controversy which ensued as to the adoption on the Liverpool and Manchester Railway of locomotive or fixed engines, Mr. Locke assisted Mr. Robert Stephenson in making numerous experiments with the existing locomotives (at many of which I was present), and these two gentlemen produced a joint report in favour of locomotive engines, in answer to the report of Messrs. Walker and Rastrick in favour of fixed engines, which substantially settled the question as to the adoption of locomotive engines over fixed engines, or any other system of motive power, on that railway. This report was printed as a pamphlet, and had great influence at that period in determining the use of locomotive engines.

After the Liverpool and Manchester Railway was completed, the projection of the Warrington Branch to Birmingham was revived, and

the line was commenced in 1832. Mr. George Stephenson was at first appointed engineer, but it was subsequently executed by Mr. Locke, and denominated the Grand Junction Railway, and was opened on the 6th July, 1837. It included some heavy works, such as the Dutton Vale Viaduct, and some heavy bridges. It was here, I believe, that the first double-headed rail, fastened to the chairs with wooden keys, was adopted, and which has since been almost exclusively used, as a mode of fastening the rails to the chairs.

The success of this line of railway, as a commercial speculation, had a considerable effect on the public mind in favour of railways, and such success being associated with what was deemed to be a very economical construction of a railway, established Mr. Locke in his profession as a railway engineer; and not only so generally, but particularly, as an economical and successful engineer, and which, no doubt, contributed greatly towards the reputation which he afterwards attained in that respect as an engineer. The Lancaster and Preston Railway was commenced in 1837, Mr. Locke being appointed engineer, and was opened in 1840; and then the Sheffield and Manchester. A line from London to Southampton was likewise projected, which was eventually constructed under Mr. Locke's direction. The first section, from Nine Elms to Woking, was opened on the 21st May, 1838, and the entire line on the 11th May, 1840. The Micheldever embankment, about ninety feet in height, was one of the heaviest works; and Mr. Locke, in the execution of this line, struggled hard, and to a considerable extent succeeded, in sustaining the reputation he had previously acquired in the construction of the Grand Junction Railway, viz., that of applying the strictest economy in the construction of railways.

The execution of the London and Southampton Line brought him into connection with the construction of some important lines of railway on the continent. It was a part of the scheme of the promoters of the Southampton Line to accomplish a connection with France, and with Paris. Hence a line from Paris to Rouen was projected, in which some of the directors and several of the shareholders of the Southampton Line took an interest. The able secretary of the Southampton Line, Mr. Reid, joined the directory of the French Line, Mr. Locke being engineer. This was followed by Mr. Locke being appointed engineer to the Rouen and Havre, Paris and Lyons, Caen and Cherbourg, and other lines, in the construction of which he was consulted. For the Paris and Rouen Line he received, in 1845, the decoration of the Legion

of Honour from King Louis Philippe. He also designed and superintended the line between Barcelona and Mataro, in Spain; and the Dutch Rhenish Railway.

While, however, he was employed in the engineering and construction of the Continental lines, he did not lose sight of those of his native country, neither did his countrymen lose sight of him. To assist him in his multifarious duties he associated himself with, and took into partnership in his professional practice, Mr. John Edward Errington; and together they constructed the Lancaster and Carlisle, the East Lancashire, the Caledonian, the Scottish Central, the Scottish Midland, the Aberdeen Railways, and the Greenock Railway and Docks. In the construction of these works, Mr. Locke and his coadjutor struggled hard and successfully in carrying out the system of economy from which Locke had started in life; and it may be instanced as a proof of such a desire, that the Caledonian Railway, though it passed through a very rough and uneven country, was executed without a single tunnel, and, together with the platforms and roadside stations, was constructed for less than £16,000 a mile.

In studying Mr. Locke's career as a railway engineer, that of economy and minute practical detail and accuracy, and untiring application and industry were the essential characteristics. The whole bent of his energies was devoted to these principles, they were, in fact, his constitutional genius; he was essentially a man of detail, and the constant bent of his mind being applied thereto, made him an adept in that respect with whom few were able to compete, none to excel. Contrasted with his contemporaries, Mr. Robert Stephenson and Mr. Brunel, it has been said that Locke has not given us a Britannia or Victoria Bridge of the former, or the Saltash and other gigantic works of the latter gentleman. True, he has not, but the whole bent of his mind being based on economy and detail, he studiously avoided such works in the execution of the railways entrusted to him; and he would weigh, with commercial minutiæ the difference of cost between going round a hill and going through it, and it was in this that he might be said to rival if not excel these eminent engineers. Perhaps, with such a bent of genius, his mind was not, constitutionally considered, so well adapted as the towering genius of Brunel, or the more sober, but probably equally expansive genius of Robert Stephenson, for the contemplation and execution of such gigantic works; but in the sphere in which he elected to pursue, he certainly attained equal eminence and success; and we certainly know that he directed the execu-

tion of equally extensive works as either of these gentlemen, and overcame all the obstacles which presented themselves on these extensive lines of railway. A portion of Mr. Locke's address to the Institute of Civil Engineers, when President, has been very appropriately quoted by the present President of that Institution, Mr. Bidder, as characteristic of the principles which he had laid down as his guidance in his profession. He said, "Let us consider the principle on which public works are now undertaken, the motives that supply those abundant means by which alone they become possible. It must be seen that the problem proposed on such grounds to practical science is not merely the execution of certain works, but rather their arrangement and construction in a manner calculated to realise the objects in which they originate;" and, "in every point of view, therefore, whether especially considering that it is the triumph of science to solve the whole of every problem submitted to it, and not a part only, or regarding its general relations to the objects of modern society in inviting its exercise, it will be seen that the financial result of their joint operation is not their least important feature, and that the appreciation of this side of the question really concerns the engineer no less than the statesman or the capitalist;" and Mr. Bidder, no mean authority, adds, "those who had watched the career of Mr. Locke were well aware how pertinaciously he adhered to these rules. It was not that he feared engineering difficulties, for when they were inevitable he encountered and overcame them with skill, as, for instance, in the works of the Manchester and Sheffield Railway. But his great anxiety, and which secured for him the confidence of a large body of capitalists, was to attain his object by avoiding difficult and expensive works, from a desire that all the works on which he engaged should be commercially successful. And then Mr. Bidder adds, "that whilst establishing his reputation as an economical engineer, he turned his attention to the locomotive engine (in which he had from the earliest period the greatest confidence), and to tax its powers for overcoming steeper gradients than had hitherto been deemed compatible with economy and safety." Nothing could more strikingly exhibit his adherence to these principles than his conduct as regarded the application of the locomotive engine. His early study of that engine, and the experiments which he made in conjunction with Mr. Robert Stephenson made him thoroughly acquainted with its powers and capabilities; and he certainly imposed upon that machine tasks which no other engineer had attempted, and which, more than any other course of proceeding,

contributed in developing its powers, and with the practical aid of his coadjutor, Mr. Robert Stephenson, raised it up to that state of perfection which we see exhibited every day.

It was laid down as a principle by Mr. George Stephenson, in the early days of railway engineering, that no gradient should be more than 1 in 330; and so deeply and firmly rooted was this principle in Mr. Stephenson's mind, that he ever fought against steep gradients. He deprecated them even to the time of his death, and could not be made to approve, as a principle, of other than very moderate gradients. He would incur considerable outlay in the first cost of a railway to secure favourable gradients, which, he always contended, would be ultimately more than compensated for by the diminished cost of working the line. Mr. Locke, on the other hand, keeping steadily in view his, as deeply rooted principle of economical construction, used steeper gradients, depending upon the powers of the then locomotives, and the probable improvements in these machines, to surmount them; and the result has so far proved that he anticipated correctly, that the passengers find very little difference in the rate of travelling over the steeper gradients of the Western Coast and Central Lines of Scotland, than along the more moderate gradients of the Midland and Eastern Coast Lines from London to Scotland. With heavy trains there is, no doubt, a difference, the steeper gradients requiring heavier and, of course, more costly engines, and the traction is consequently more expensive; the whole question being, however, one of comparative cost between the increased expenditure of capital and less annual cost, against the less expenditure of capital and greater annual cost. I need scarcely say, that each of these gentlemen were peculiarly competent to investigate the propriety of adoption of their respective principles; but I much doubt, so tenaciously did they adhere to their respective dogmas, that they ever entirely agreed on any isolated case. I well recollect the jobation I got from "Old George," as we used to designate him, for giving evidence for Mr. Locke in favour of the adoption of, I think, ten miles of gradients of one in seventy on the Scottish Central Line of Railway.

In the battle of the gauges, Mr. Locke adopted the side of the narrow gauge, which he supported with his wonted energy, and all his lines were laid down on the narrow gauge principle; and hence in the Western Railways he came in contact with the Great Western Railway and its broad gauge branches. The battle did not end, therefore, with the question of which was the best width of gauge, but extended to the

practical adoption of one or other of the systems in the debateable country of the West of England; and even after the broad gauge was executed to Exeter, it was a continual fight between the South-Western and the Great Western interests which of them should obtain the traffic; and it was only a short time before his death that Mr. Locke succeeded in pushing the narrow gauge line to Exeter, the capital of the West of England, and the great point of contention between the narrow and broad gauges.

In the exercise of his profession, and while examining a tunnel on the Caen Line of Railway in France, Mr. Locke met with an accident by the fall of a scaffold, which disabled him for some time from walking; he recovered from this, however, though he was never quite so strong as before, still he enjoyed good health up to the period of his fatal illness. He was excessively fond of shooting as an annual relaxation from the pressure of business, and rented a shooting-box in Annandale, near Moffat. At the commencement of the grouse shooting in August last, he was at his usual shooting quarters at Moffat, and had been there about five weeks, when he was seized with a sudden, and, as it turned out, a fatal illness, which resisted all the best efforts of medical skill to avert. On the preceding morning, at an early hour, he became aware that he was not in his usual state of health. Feeling intense internal pain, he rang for his servant, and, as if sensible of his peril, he at once sent for medical aid, and Dr. Muro, of Moffat, with Dr. Hunter, speedily reached him, and rendered him all the professional service in their power, but their efforts to mitigate the pain or arrest the progress of the disease were only partially successful. The seizure took a rapid and fatal course, and a little after eight o'clock on the morning of Tuesday, the 18th of September, he died. The body was removed to his residence in Lowdnes Square, London, on Wednesday evening, accompanied by his nephew, William Locke, Esq., C.E., and was interred at Kensall Green Cemetery on the 25th of September, 1860. The funeral was not attended with that number of people which followed the remains of the late Robert Stephenson to Westminster Abbey, at which he was one of the pall bearers, Mrs. Locke having declined a public funeral; but the number of his friends, and members of the profession from all parts of the country, were most numerous, and shewed the esteem in which he was held.

Mr. Locke was a member of the Royal Society, and at the time of his death, was a past President of the Institute of Civil Engineers, having

been President in the year 1859, and on the opening of the session in November, delivered a most feeling address announcing the death of his two distinguished colleagues in the profession, Mr. Brunel and Mr. Robert Stephenson. He was also elected, a few weeks before his death, a Vice-President of the Institute of Mining Engineers, at their Annual Meeting in August, 1860; and he would receive the announcement thereof at Moffat, a week or two before his death. He was also a Member of Parliament, having sat for the borough of Honiton from 1847 to the time of his death, being proprietor of the Lordship of the Manor of that place.

No two men, probably, as private gentlemen, and in their public conduct, ever acquired the confidence and esteem of so large a class of their fellow members, as Mr. Robert Stephenson and Mr. Locke. I have already given in detail my feelings as regards the former of these gentlemen; allow me here to say, as regards the latter, that of his private character, and of his urbanity and general bearing towards every one with whom he came in contact, and especially in his profession, it is unnecessary for me to descant; his loss will be long felt in his profession, and his friends and relatives will long mourn over the deprivation which they have sustained in the loss of so excellent a person.

We must all bow to the acts of Divine Providence, and it is not for us to scrutinise such dispensations as those which we have, almost simultaneously, been afflicted with; but it has been remarked as an extraordinary coincidence, that three of the most eminent railway engineers, following in the footsteps of the great father of railways, George Stephenson, should, so shortly after his death, be removed from us—accelerated, no doubt, by the undue tension thrown upon their mental and physical powers by the very laborious and multifarious duties of their profession. The incessant mental and physical exertions bestowed by Mr. Brunel on the "Great Eastern" steamship, no doubt shattered his frame, and tended to produce the results which all deplore. The continuous mental and physical exertions of Mr. Robert Stephenson, in the conception and in the details of execution of the, in every case, original and gigantic bridges across the Straits of Bangor, the Nile, and the St. Lawrence, no doubt laid the foundation of those maladies which ultimately exhausted his system, and which at last terminated fatally. And the incessant, and laborious, and constant exertion of the duties of his profession by Mr. Locke, no doubt sapped his physical powers, and rendered him unable to resist the attack by

which he was so suddenly removed from this world. The cord has been too tightly drawn—the tension too great; and though, at ages comparatively short, these eminent men were removed from us, they had *lived* in the multiplicity and magnitude of their works, greatly beyond the period of life of the ordinary race of mortals.

Mr. Boyd's paper "On the Geology of the Northern Part of Northumberland, and the Coal Seams connected therewith," was then read.

The meeting then adjourned.

[Owing to the time occupied in preparing the description and plans of Mr. Boyd's paper, it could not be printed in time for this month's proceedings; it will, therefore, be given in the proceedings of a subsequent month.]

NORTH OF ENGLAND INSTITUTE
OF
MINING ENGINEERS.

GENERAL MEETING, THURSDAY, FEBRUARY 7, 1861, IN THE ROOMS OF THE INSTITUTE, WESTGATE STREET, NEWCASTLE-UPON-TYNE.

P. S. Reid, Esq., in the Chair.

The monthly meeting of the Institute was held to-day, and in the absence of the President, the chair was taken by Mr. P. S. Reid, on the motion of Mr. T. Y. Hall, seconded by Mr. J. R. Liddell.

The Secretary read the following report of the Finance Committee:—

"TO THE COUNCIL OF THE NORTH OF ENGLAND INSTITUTE OF MINING ENGINEERS.

"Gentlemen,—The Finance Committee, on fully considering the subjects referred to their attention, relating to the general management of the finances, the stock of books published by the Society as well as those in the library, the models, specimens, plans, &c., are of opinion that the growing requirements of the Institution demand, on the part of its promoters, more complete and active supervision.

"With respect to the manner in which the printing and distribution of the papers of the Institute, and the general storing of undistributed papers, are conducted, it appears that the printer sends by post, or otherwise, a copy of each month's proceedings, as they are struck off, to each member.

"Sometimes members call at the printer's, alleging that they have not received their copies, and the fact of non-delivery being difficult to

bring home to the post-office authorities, he has, on several occasions, been compelled to furnish duplicate copies.

"By this means the set required to complete a volume is broken into, and much loss is occasioned to the Institute, no account being kept of any extra copies issued to members. The extra parts printed for sale remain in the printer's hands in loose sheets—the plans, engravings, &c., in one lot, and the letter-press in another; so that it is quite impossible, unless with great labour, to say how many complete volumes remain in store.

"Your Committee, in offering the following recommendations, beg to state that the printer has expressed himself perfectly agreeable and desirous of carrying out any arrangement which may be decided on.

"We think, in the first place, that in future it should be made a rule that no duplicate copies be issued to any of the members, unless by written order direct from the Council, so that any neglect on the part of the post-office, or elsewhere, be fully inquired into.

"We also think the members will agree that any member losing any of his parts, cannot expect the Institute to replace them, and that a rule of this sort should be strictly adhered to.

"We would recommend, in future, that all loose parts be stitched together and stored, and that none be kept in sheets; and that two months after the last part of the volume is issued, the whole should be bound, either in the permanent style of those already in stock, or in cloth, as the Council may decide.

"We also advise that heads be kept at the printing-office, in a proper book for this purpose, showing the numbers and distribution of each part.

"Also, that the number of sheets entered to stock be carried to a ledger account, under a proper head kept for each volume—the loose numbers being debited to the volume, and the sales and distribution credited.

"The foregoing arrangements should, we beg to suggest, be immediately carried out, and if the following part of our report be adopted, it would continue in force as hereafter named.

"We think that it will be impossible to expect that sub-committees of the Institute or Council can attend and do justice to all the many wants of a Society like this.

"We therefore suggest that a paid Secretary be appointed (who shall be a member of the Institute), during the pleasure of the Council, and whose tenure of office shall be terminable by three calendar months'

notice on either side, and that such Secretary be expected to devote a sufficient time to the fulfilment of the duties of his situation, which shall be the properly keeping up of the scientific correspondence of the Institute, the classification of its property, and general furtherance of its objects.

"His attendance to be at the rooms of the Mining Institute twice a-week, and to have the editorial charge of the furtherance of all publications emanating from the members, subject to the approval and sanction of the Council.

"The subjects of rooms, and arrangements for keeping up the Institute property, demand the immediate attention of the Council.

"We cannot help saying, that the arrangement with the Coal Trade Association, so far as it has gone in the infancy of the Mining Institute, has been a most beneficial one; yet still, looking at the magnitude of the interests which will be discussed as the Society becomes older, and as the growing necessity for publicity in all its proceedings becomes more felt, as well as the fact that it ought, to a certain extent, to be a self-supporting Institution, we feel prompted to the conclusion that that arrangement now demands the attention of the Council as to its permanence.

"In connection with this, there is also the question of whether it is desirable to avoid in any way the mixing up of its proceedings or property, as a scientific society, with one such as that of the Coal Trade Association, devoted entirely to commerce.

"We would also suggest that, in future, the books and accounts in the hands of the Treasurer, as well as all accounts, should be closed to an earlier period than hitherto, say to the 30th of June in each year, and that the whole lie on the table from the 15th of July to the annual general meeting in August, for the inspection of the members.

"We would also recommend that, in the event of a Secretary, as before alluded to, being appointed, his remuneration be such as to encourage him to devote as much time as possible to the action and furtherance of the objects of the Institute; in short, to be in the position of managing director of its operations, or general factotum, under the care and surveillance of the Council.

"We also think he should be a resident in Newcastle, or within convenient distance and telegraphic communication.

"We are, Gentlemen, your obedient Servants,

"P. S. REID.
"JOHN R. LIDDELL.
"CUTH. BERKLEY.

"*January* 24*th*, 1861."

Mr. BERKLEY then moved, "That the Finance Committee's report be printed in the proceedings of the Institute, and the discussion of it postponed until it is in the hands of the members."

Mr. HALL seconded the motion, which was agreed to.

The SECRETARY then read a report of the Council relative to holding a meeting in some central town, the place recommended being Birmingham, and the time for holding it, July. A resolution was proposed by the Council, "That the committee appointed to carry out this object, by the general meetings in November and December, be requested to lose no time in taking the necessary steps to complete it, and be authorised to add to their number such members of the Institute as may assist them in carrying out the object in view."

Mr. BERKLEY moved the adoption of this report and its suggestions.

Mr. HALL seconded the motion, which was carried unanimously.

Mr. Charles Ashley Shute, Thornley Vicarage, Ferry Hill; Mr. G. J. Crofton, and Mr. R. L. Simpson, of Crook, near Darlington; Mr. George Laverick, Plymouth Iron Works, Merthyr Tydvil, Glamorganshire; and Mr. William Cook, East Holywell Colliery, Earsdon, near Newcastle, were then elected members of the Institute.

A paper was then read by the CHAIRMAN, from Mr. William Watson, descriptive of the use of Cement Walling, as manufactured by Mr. I. C. Johnson, as a substitute for metal tubbing in shafts.

Mr. I. C. JOHNSON attended to give explanations on the subject of this paper. He said he had had experiments tried with the blocks of cement walling, such as those in the room, which were ten inches in the bed, and about twelve inches in height, and of a very sound, neat appearance; and he found they were especially qualified for the purpose of sustaining pressures of water, and, in fact, that they would sustain exceedingly great pressure and strain.

The CHAIRMAN remarked, with reference to metal tubbing, that the great difficulty experienced in the county of Durham, was to get it to withstand the heat in upcast shafts, as well as the oxidation which, in some instances, so thinned the metal as to cause it to fail altogether. The heat was sometimes as great as 300 degrees. In some instances upcast shafts, as a protection to the iron, were cased with fire-brick. If it could be shown that it was likely to supersede the use of cast iron in these respects, it would be valuable.

Mr. JOHNSON said, all we want to know is what is required of it?

The CHAIRMAN—I have seen trass and hydraulic lime used on the Rhine, in Prussia. It has some analogy to this walling, and stands great pressure.

Mr. JOHNSON said, it was easy to prove, by direct experiment, the great pressure this walling will bear, and he would have great pleasure in getting up experiments, to convince the meeting of its strength.

Mr. BERKLEY—Is it permeable to water?

Mr. JOHNSON—It is not permeable.

Mr. DAGLISH—There is sometimes a variation of from fifty to two hundred degrees. Will the expansion not affect it?

Mr. JOHNSON—It will bear 500 degrees without being calcined.

Mr. GREENWELL—What pressure will it bear as compared to brick?

Mr. JOHNSON—A block of this size will bear a pressure of eighteen tons on the square foot. It is ten inches thick.

Mr. GREENWELL—Is it as cheap as the ordinary stone you get in this neighbourhood?

Mr. JOHNSON—It is as cheap, but *that* stone would be porous. This cement is 1s. per square foot, ten inches thick.

The CHAIRMAN—There are some pits in South Durham in which the cast iron tubbing is compelled to be lined with fire-brick, on account of the free sulphuric acid eating away the metal. How would cement stand the acid?

Mr. JOHNSON—Very powerful concentrated acid would certainly decompose it.

Mr. DAGLISH—The acid is concentrated.

Mr. JOHNSON—It does not come on this in a state of liquid?

Mr. DAGLISH—Yes, in a state of liquid.

Mr. BERKLEY—It trickles down, and the water is gradually evaporated, whilst the acid remains. Suppose any flaw to occur in your cement walling, or that the cement, in its manufacture, was not perfectly attended to by the workmen, how could you remedy this?

Mr. JOHNSON—It is scarcely possible that that could happen.

Mr. GREENWELL—During the time of setting, it might possibly waste away.

The CHAIRMAN, in dismissing the subject, said it was a most important and valuable one, and that he was sure he spoke the feelings of the coal trade when he said they would be quite alive to its merits; and if Mr. Johnson would come forward with such fresh details as he could put

together, which would bear on the subject, at the meeting in March, he might rely upon it, that the Institute would not lose sight of it, and be glad to discuss it further.

Mr. Berkley then, in the absence of Mr. W. Armstrong, read a paper by that gentleman "On Ventilating Furnaces, and their Elasticity of Action."

Mr. Greenwell observed, that there were two points which occurred to him during the reading of this paper. First, as to the shape of the furnace. At the back you have what is called a bridge; and unless you make the top of the arch to slope, so as to have the same space above the bridge that you have in front, you throttle the air at the back of the furnace. The next point is this—Mr. Armstrong speaks of the destruction of iron work in the upcast shaft, and at the same time proposes iron brattice. The objection to iron brattice is met by having a brattice of brick.

Mr. Daglish—The objection to iron is when it is moist. If you keep it at the top there can be no objection.

The Chairman—I am under the impression that we have an instance of the brick brattice in the Ouston Colliery. If I am correct, it is a mixture of iron and brick.

Mr. Berkley, referring to the diagrams, said they were merely rough sketches to illustrate the paper. Mr. Armstrong proposed, if the paper was printed, to furnish proper drawings.

Mr. Greenwell—There is also another point. Mr. Armstrong attaches great weight to the absorption of the heat of the air at the sides. This requires a great deal of explanation. There is some change in the form of the air when rarefied, which causes me to think there is more due to the atomic form or development of latent heat than to any abstraction of caloric by the sides of the mine or brick work.

The Chairman—I agree with this. We do not certainly get the power from rarefying furnaces we should have for the fuel consumed. I believe it is generally admitted we get a greater amount of duty for the fuel used in cases where improved mechanical methods of ventilation are adopted.

Mr. Greenwell adduced the case of a condensing syringe, in which, by forcing the plunger smartly down, you acquire such a degree of heat as will ignite tinder. Now, the question is, how the air is changed in its atomic condition on the reception of heat.

The CHAIRMAN—There can be no question that whatever heat is acquired by air in any way, it very soon loses it when once deprived of radiating heat or motive power.

Mr. DAGLISH—Some advocate having the furnace at a distance from the shaft, because heat is given off from the heated brick-work when the fire is low, and which is given off for long after the furnace is extinguished. In some cases I know of, the furnace is fed with fresh air.

The CHAIRMAN—I know similar instances in which the passage between the furnace and the upcast shaft was so tortuous as to necessitate fresh air for its proper combustion, and it was applied in large quantities. Again, I know instances in which it is thought to be too near the upcast shaft, and where the phenomenon called "natural brattice" is thought to obtain. It is, therefore, a very necessary point to discuss, which is the best point to place a furnace at; and also, secondly, which is the best form of furnace to secure the greatest effect. The Institute is indebted to Mr. Armstrong for his valuable paper, directing attention to so important a matter.

Mr. GREENWELL—It is a subject which will admit of a very great deal of discussion.

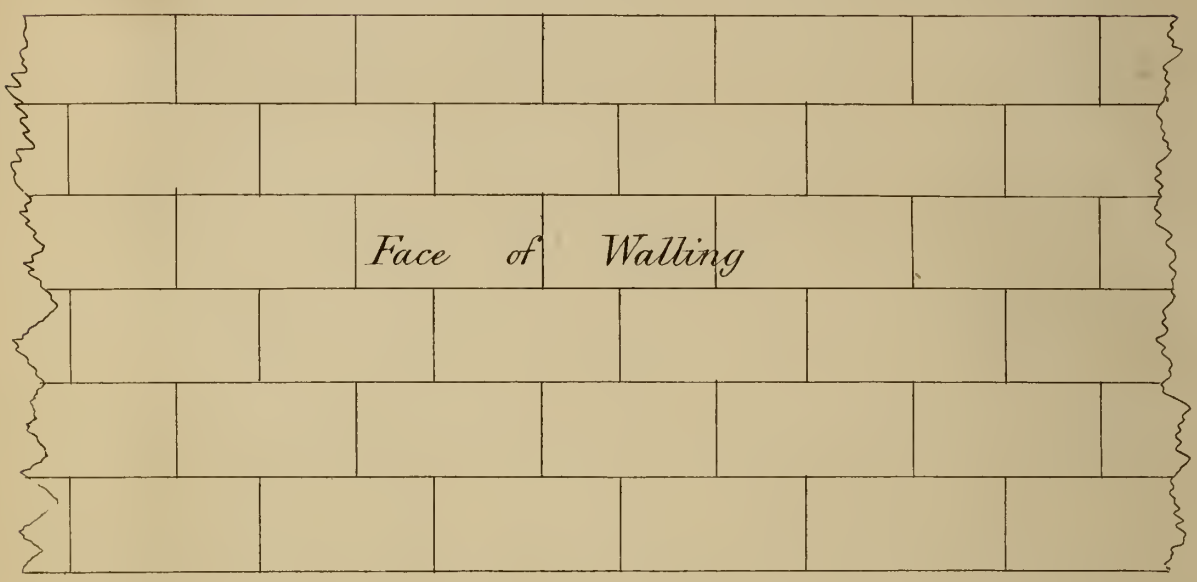
Before the meeting separated, Mr. HURST produced some curious specimens of brown coal, or lignite, from the Upper Rhine, sent to the Institute by Dr. Richardson, together with samples of paraffin made from it.

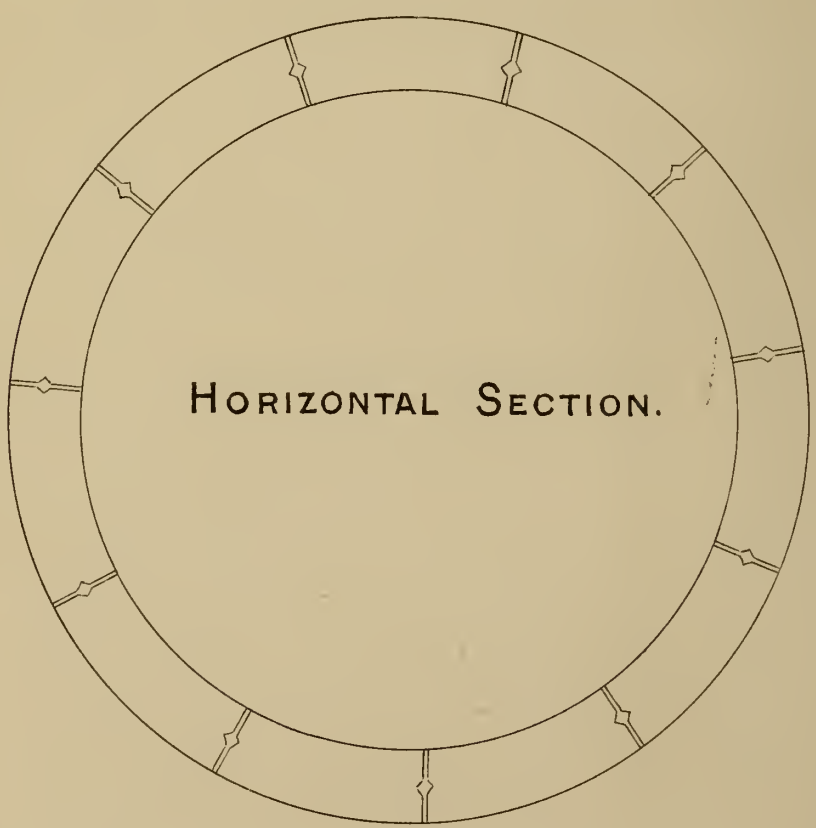
The CHAIRMAN remarked, that coal had been generally understood as either black or brown, whereas the specimen produced was more like the colour of chalk or magnesian limestone, being of a whitish brown. It ought to have been produced at the Boghead trial on the question of "What is coal?"

The meeting then adjourned.

Sketch of Cement Walling.

(Mr. Watson's Paper.)





Lithographed by A. Reid, Newcastle

ON THE

USE OF CEMENT FOR WALLING,

AS A

SUBSTITUTE FOR METAL TUBBING IN SHAFTS.

By Mr. W. WATSON.

In drawing your attention to a subject of great moment in the general pursuits of the mining world, viz., the application of tubbing back heavy feeders of water, unavoidably met with in the winning of new collieries, I may be allowed to state that it is well known that previous to the introduction of metal caissons for this purpose, three inch wooden planking was used, spiked to wooden cribs, afterwards succeeded by freestone walling; but either of these could only be used at moderate pressures, the freestone, as you are all aware, being porous and insufficient to resist an ordinary pressure. Metal tubbing of requisite strength and thickness was then found necessary to overcome the difficulty of passing through strata heavily watered, varying in cost according to the pressure to be resisted, say from £15 to £45 or £50 per fathom (of six feet), exclusive of sheathing and wedging, yet we find, at the present day, that such metal tubbing is insufficient and not to be relied upon, particularly in *upcast shafts*, where it is acted upon by the heated sulphurs, which is found in time to corrode, and ultimately loses its durability by the action of the water upon the metal, thus rendering it comparatively useless.

I now take the liberty of drawing your attention to a *manufactured cement* which I have had made into segments (by Mr. I. C. Johnson's assistance) of ten inches in the bed, and beveled to a sweep of fourteen feet radius, which, being impervious to water, and capable (if I may use the expression) of resisting any pressure that can or likely be brought to bear against it, its properties being such *that it does not decompose by being subjected to wet, cold, or heated situations*, such as are found

to prevail in all coal mining districts. You will observe, from an inspection of the blocks laid before you, that they are moulded ready to the requisite sweep of the supposed shaft, that in placing such blocks the joints would be, of course, checkered (or, in general phrase, "broken") and set in mortar composed of the same material (cement), consequently would become one solid ring or walling the whole height of proposed tubbing.

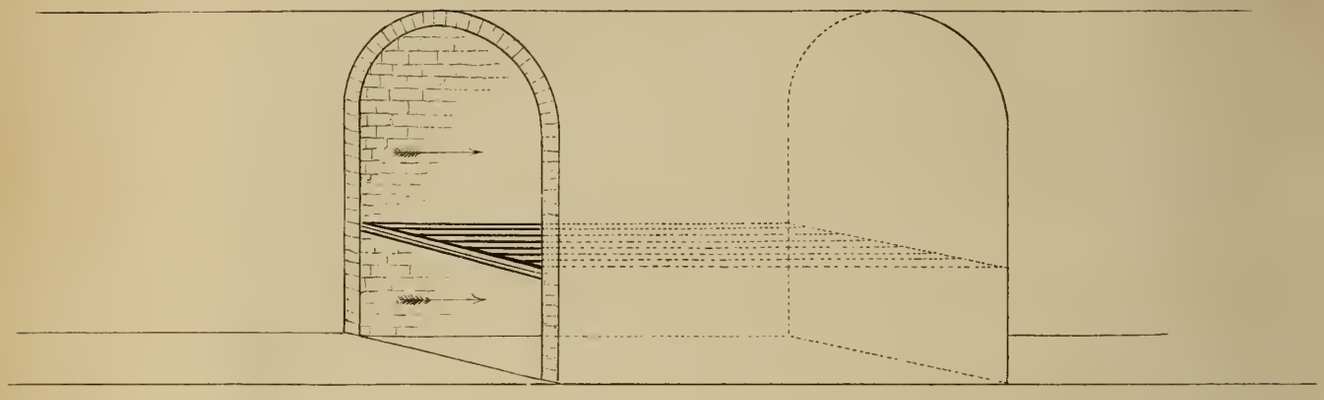
If, then, we have procured a substitute preferable to iron, we have, I may say, achieved a great object in itself; yet that is not all, for if we inspect the following tabular form of cost, we observe that the cement casing can be made complete at a comparative low cost per fathom to that made of iron :—

Altitude.	Pressure per Square Inch.	Requires Metal Tubbing.	Weight per Fathom.	At per Ton.	Cost per Fathom.	Price of Cement compared with Metal.	
In Fathoms.	lbs. to lbs.	Inches thick.	Tons. Cwts. lbs.		£ s. d.	Depth of Bed.	£ s. d.
						In.	
From 0 to 30	0 to 82	¾	5 6 20	£6	31 17 0	6	7 1 0
,, 30 to 50	82 to 140	1	7 2 12	,,	42 12 6	7	8 5 0
,, 50 to 60	140 to 172	1¼	8 18 0	,,	53 8 0	8	9 8 0
,, 60 to 70	172 to 195	1½	10 13 8	,,	64 2 0	9	10 15 6

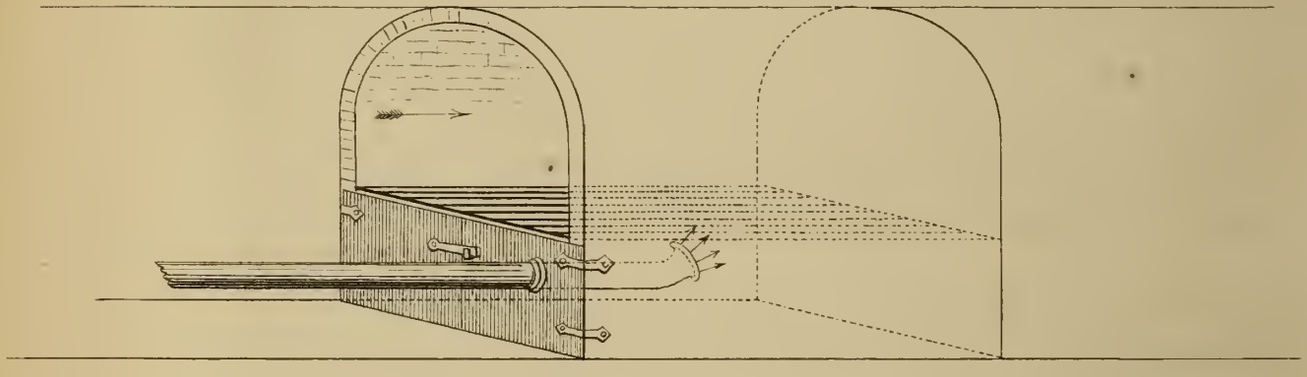
The result of the above table shows at once a considerable saving in capital, which is admitted another important consideration for the mining engineer to attend to.

Cement of this description has many good properties, which can only be explained by those who have made it their study by a long-continued practice; and I am much indebted to Mr. I. C. Johnson for the information I have received, which induced me to bring the matter before you for consideration.

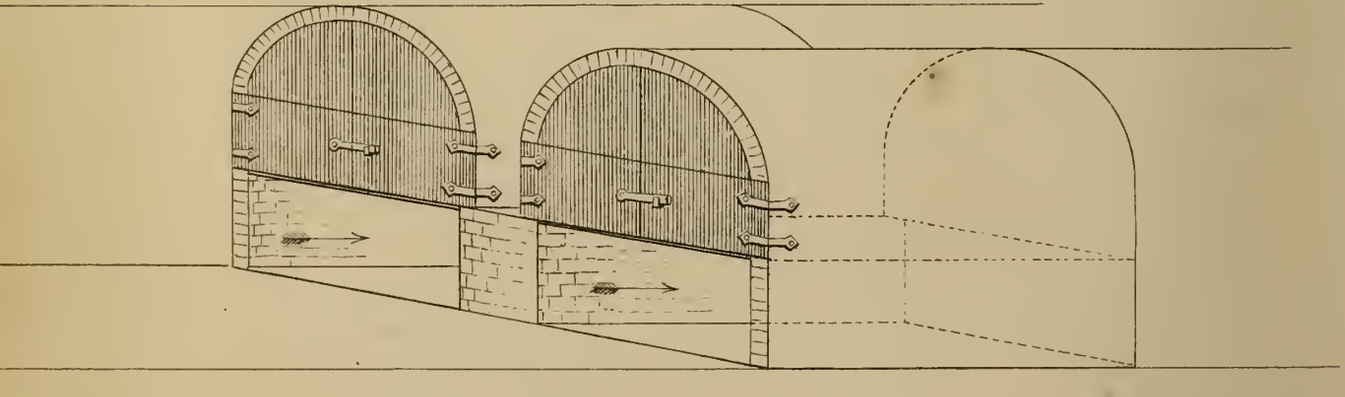
COMMON FURNACE



CAWBER HALL FURNACE



PEMBERTON FURNACE



Lithographed by R. Reid Newcastle

ON

VENTILATING FURNACES,

AND THEIR ELASTICITY OF ACTION.

By Mr. WILLIAM ARMSTRONG.

Although the laws which govern a ventilating column are now pretty well understood, and the various devices for abating the friction it sustains, whether by enlarging the area of the air passages, or by splitting and subdividing the several currents, have been fully and scientifically treated by several members of the Institute, there still remains for consideration the motive force itself—its maximum effect under given conditions, its elasticity as a ventilating power, and the best forms for its construction.

We propose to discuss very generally the following facts and propositions, with a view to elicit discussion, and so develope the scientific principles in the construction and position of a furnace.

I.—The position of a furnace with relation to the upcast shaft, and its various forms of construction.

II.—The general laws which limit ventilation.

III.—The most efficient form and position of a furnace.

IV.—The impediments to the application of the principle, and their remedies.

V.—The elasticity of the furnace, and its range of action.

I.—It must be obvious to any one visiting collieries under different management, how empirical is the law in the position and plan of a furnace.

We find some furnaces so erected that the area over the fire bars is large, so as to afford as little obstruction as possible to the air current—others confine the air partially under the fire bars, the area of the furnace above being purposely reduced, to force the air through the fire—others

have a front arch, with or without what are called ventilating holes, which arch, coming down within a short distance of the fire, leaves the remaining space behind open, and of full size, to admit the sudden expansion of the air after its first contact with the fire—whilst others have the upper section partially closed by doors, and thus, at the risk of straitening the air passage, seek only a high temperature in the upcast shaft.

Then there are furnaces with large side drifts, varying with the fancy of the architect, who, sometimes wedded to strange theories of side openings and spherical inlets, expends his ingenuity in getting the air entangled amongst a number of pillars, around which it must elbow itself before its final exit over the furnace.

These irregularities of pattern, and many other fantastic designs, exist in the simple furnace, where the whole of the return air is passed over the fire.

And there is the further complication of the problem, when a portion of the return air is passed over the fire, and the remainder, subject to occasional intermixture with gas, is conducted into the upcast shaft at some point out of reach of the flame; and occasionally, in exceptional cases, where, either from the small ventilating current, or where the discharge of gas is excessive, all the return air is passed into the upcast at some point above the furnace—the furnace being maintained wholly by the abstraction of a small current of fresh air from the downcast shaft.

It is clear that very different forms of construction are needed to meet these several cases, depending upon the greater or less per centage of return air passed into the shaft, or over the furnace, and the ratio of the fresh air to the return air entering the upcast shaft, when the latter is excluded from the furnace; and it is equally clear that for each of these modes of ventilation there is a form and adaptation of arrangement, which with trifling modification to the circumstances of each case, will admit of a maximum effect.

And there is equal diversity of practice in the position of the furnace in its relation to the upcast shaft. In some collieries the furnace is placed at the bottom, and shallow pits are sometimes surmounted with cupolas, as they are locally termed, to add to the effect; whereas, in other and deeper collieries, the furnace is placed at very varying distances from the upcast.

II.—Nothing is better settled than that the ventilating current is produced by the difference of density of the downcast and upcast columns,

due chiefly to difference of temperature—the amount of current varying with the square root of this difference between the columns respectively; so that, if it were necessary to double an air current, the difference of temperature would have to be quadrupled, and hence there is a speedy limit to any further extension in this direction. Again, the amount of current varies with the square root of the depths of the upcast; and here, similarly, a double current, requiring four times the height of chimney, stops further improvement after a certain point.

And when to these laws, which operate so suddenly against the development of furnace power, is added the still more stringent law, that the resistance to an air current increases with the square of its velocity, and inversely as the area of the spaces traversed, it will be at once seen how difficult it is, in cases of sudden emergency, to look to a furnace, under ordinary conditions, for any material augmentation of its power.

III.—The true principles for securing the most efficient action of a furnace are—

First, to maintain as high a temperature as possible in the upcast shaft, for, other things being equal, the motive force of the furnace is only capable of expansion in this way.

And, secondly, the position of the furnace should be at the bottom of the upcast, and these, we take it, are the two cardinal points to attend to for securing its maximum force.

The problem being so to construct the furnace and regulate the admission of the return air over and through it, under ordinary circumstances, and so to graduate the admixture of a current of fresh air to stimulate the combustion of the fuel as shall, whilst affording a full area to the air current, generate the highest heat in the shaft, and thus secure the highest ventilation of which the furnace is capable. And we suggest, that the application of these principles to all the various phases of furnace action to which we have alluded, is the chief desideratum in this branch of our enquiry.

IV.—At the outset we are met with difficulties in the application of the principles just enumerated.

In collieries having shafts purposely set apart to the use of a furnace, and these, especially in the midland counties, are of frequent occurrence, no impediment exists to the full application of either principle; the furnace can be placed so that the heated air shall escape directly into the shaft without any intervening flue way, and the temperature can be elevated with impunity.

But when the upcast is but one section of a larger and single pit, the sinking of which, from engineering difficulties, in quicksands and loose alluvial deposit, has involved a large expenditure, and wherein a brattice or wooden partition is all that separates the air currents of a deep mine, and when these conditions are still further complicated in having the upcast section of the shaft appropriated to coal drawing, it becomes absolutely necessary to set back the furnace, so as to prevent the flame and occasional sparks whilst stoking it from reaching the brattice, thus necessitating a long flue-way to the upcast.

Here the retarding forces are very considerable. Much of the temperature of the heated air is lost or absorbed in the flue-way, from the rapid conducting power of the circumference of the drift, and the initial temperature of the column is hence lessened when it enters the shaft. The water which is distributed over the surface of the brattice scatters and falls over the area of the shaft, and, besides counteracting the upward draught, robs it speedily of its heat, the numerous crevices in the brattice, by letting in the cold air, also contribute materially to the same result, and these drawbacks are all independent of the natural conduction of heat laterally into the strata of the pit. The loss of temperature in upcast columns has frequently been noted, and the above comprise the principal of the adverse causes operating against the furnace so circumstanced as a ventilating power, and account for much of the unfavourable results of a given weight of fuel as applied to a ventilating machine and a furnace.

In collieries so situated, it is obvious that the maximum difference of density in the two sections of the same pit is soon reached.

And these are not the only ill effects. The smoke generated so profusely from the furnace, assisted by the heat and water, sets up the destructive action upon all the metal exposed in the pit, whether it be the tubbing, behind which the principal colliery feeders are dammed back, or the wooden apparatus for the conductors of the cage.

The character of some of these curious chemical changes I have analysed in a former paper.

And the question arises, how far these impediments to an efficient ventilation are capable of remedy.

Since the substitution of wire for the old hempen rope, one impediment is removed, and where wire slide ropes cannot displace the wood conductors, iron buntons and slides may be introduced, and thus another hindrance to a higher temperature may, to a great extent, be got rid off.

And I feel persuaded, that a malleable iron brattice, built of plates, rivetted boiler fashion, and attached to the sides of the shaft by side strings of angle iron (a double case in deep shafts may be necessary, through which a current of air might be detached) would form a strong and impervious partition, and admit of easy repair and restoration, and thus the most formidable objection would be removed to the introduction of a furnace under its most favourable conditions.

If, in addition, the shaft tub be sent back sufficiently to permit a lining of fire brick, and to which easy access would be given, all further apprehension would disappear.

Or, as a still better arrangement in those cases wherein the upper feeders of water are so considerable that the outlay of a second shaft is in many instances, from this cause, precluded, the introduction of a furnace staple under the water bearing strata, at the bottom of which the furnace could be placed, would obviate much of the inconvenience and expense arising from the pernicious influence of the smoke upon the cage conductors and brattice, and would limit the waste to the upper section of the shaft, where the temperature of the heated current would be considerably reduced.

A shaft fitted up with such apparatus, or aided by an auxiliary staple, would go far to avoid the necessity of removing the furnace from the shaft, and except as to the increased cost of upholding the iron work, and the trifling retardation caused by the passage of the cages, it would be equally effective with the single shaft, appropriated solely as an upcast.

As either plan just indicated would admit of the highest temperature of a column generated from a furnace, situated immediately at its base, the problem is—

How, and under what circumstances, can we obtain the highest temperature consistent with the preservation of the full area of the air return into the upcast? Nothing is more easy than by narrowing the air return to produce a high temperature of the upcast column, but this is accompanied with such an amount of friction of the ventilating current as to produce no useful result; and on the other hand, a large column of air passing over the furnace at the natural heat of the mine requires an extensive fire area to sustain the elevated temperature by which the ventilation is preserved.

V.—And it was precisely these difficulties that led to the experiments upon furnace action, which, in two instances, at the Gawber Hall Colliery, near Barnsley, and at the Pemberton Colliery, near Wigan, an

unexpected addition was found to result from a new adaptation of plan—in the former, where the whole return current was passed over the furnace, and in the latter, where the return air from the Arley Mine Seam was so charged with gas as to render it expedient that the furnace should be wholly fed with fresh air.

Both arrangements are upon the same principle so far, that the fresh air is forced through the fire bars; but at Pemberton, from the contiguity of the return, the double furnace was placed fifty yards back from the shaft.

At Gawber Hall, Mr. Sutcliffe found that all his efforts to increase the ventilating current through the old workings of this colliery were ineffectual without adding materially to his furnace area, or enlarging the returns, either alternative, under the conditions, being difficult.

With an upcast shaft six feet in diameter and 400 feet deep, the furnace four feet wide and seven feet long, placed at the bottom of the shaft, with an airway over the fire-grate of four feet high, a maximum air-current was obtained of 13,000 cubic feet per minute, with a consumption of four tons of coal in twenty-four hours.

As the furnace burnt languidly, it was suggested that the admission of fresh air might, if properly graduated, increase the furnace action without reducing the air current, and a few fifteen inch pipes were inserted between the separation doors and carried under the fire-grate of the furnace.

The effect of this, after a few trials, was to obtain a current of 15,300 cubic feet per minute, which, with 1750 feet per minute admitted by the pipe, gave 17,050 cubic feet per minute as the gross current passing between the downcast and upcast shafts.

Encouraged by this success, it was further suggested that if the pipe air was confined under the fire grate, and so forced through the fire, the front part of the furnace under the grate being barred off by iron doors, through which the pipe was inserted (see plan), that the effect would be further improved; and adjusting the pipe air, after many trials, to 2500 feet per minute, it was found that a working current of 25,000 cubic feet per minute was realized, so that the gross current passing down the downcast had now attained 27,500 cubic feet per minute, with a consumption of fuel of seven tons in the twenty-four hours. In addition to the stimulus to combustion afforded by the return air, we have here the additional force afforded by a current of compressed air, impelled through the fire with a pressure equivalent to 1·5 inch of water, or 8 lbs.

per square foot, and hence the high temperature and energetic combustion imparted to the fuel.

Here, by a very simple contrivance under very favourable conditions, an improvement of ninety-two per cent. was obtained in a working current, which served all the requirements of the colliery, and rendered unnecessary the expensive alterations which would otherwise have been needed.

The effect upon the fire was curious. The temperature was immediately elevated almost to a white heat, the rapidity of the cool air through the bars effectually protecting them from injury, and rendering their renewal, in fact, less frequent than under the old arrangement.

The stoking of the furnace was superseded, the labour of the furnacemen being confined to the mere feeding of the furnace with coal, which, from the intense combustion, was literally consumed, leaving nothing but an impalpable powder as a residuum.

With a furnace of these small dimensions, the maximum consumption upon the old plan, was four tons of coal in the twenty-four hours; whilst the simple introduction of fresh air through a small pipe with retaining doors, required seven tons to support the waste of coal, with an improvement besides in the working current of nine per cent. upon equal quantities of fuel.

And a very marked improvement was also obtained by Mr. Greener, with his twin furnaces, at Pemberton, but with the plan inverted as to the retaining doors (see plan); for, as no part of the return air was passed over the furnaces, from the cause before assigned, they were fed exclusively with fresh air below the bars, the upper section of the furnaces above the grate being shut off with doors.

With 14,100 cubic feet of fresh air passing over and under the fire grate, the doors being open, 57,436 cubic feet were realised, with a consumption of three and a quarter tons of coal, in twenty-four hours; whilst by closing the doors, and forcing the air through the grate, 65,400 cubic feet were obtained with four tons of coal. Here about fourteen per cent. increase was obtained.

In this case, however, the whole of the motive force was due to the elevated temperature acquired by 14,100 cubic feet of fresh air, the return currents entering the upcast at 62°; and the deteriorating effect is shown in the reduction of the temperature from 302°, where the returns entered the shaft, to 108° at the surface.

Under this, perhaps the most disadvantageous condition of things,

still the augmentation was almost immediate; and, contrasting as it does with the higher improvement shown in Gawber Hall, which latter may be considered as the normal adaptation of furnace arrangement for ordinary ventilation, the results are useful as showing the most and least effective position of the furnace, the object of both being to obtain the maximum current under most dissimilar conditions.

I do not adduce these experiments and their results as affording reliable data for assuring, that under any but the same conditions, will all the improvement be realised; but I am satisfied, from the few trials I have made in this district, under very unfavourable circumstances, that a largely-improved temperature is immediately generated; and where this can be sustained without peril to the shaft apparatus, a material and immediate augmentation of the air current will follow.

With upcast shafts of large area the arrangement will I think, be valuable, as dispensing with the number of furnaces necessary to support the temperature of so large a column; and, again, in limited areas or in shallow pits, it will be found equally advantageous.

One very important desideratum is obtained—an elasticity of action under complete and independent control; for, by the action of a simple slide, very varying currents may be commanded to meet the exigencies of a colliery, under all the fluctuating conditions of barometric pressure, gas discharge, and increased length of run. Between the limits of the maximum air currents of the old and improved plans of furnace arrangement, in one of the cases just cited, between 13,000 and 25,000 cubic feet per minute, a valve, with a graduated dial adjusted to the pipe drift, will, all other things being equal, afford at any time any required augmentation of the ventilation of a colliery, and this, too, with a rapidity and simplicity of action which will render it an acquisition, in many of the dilemmas of colliery supervision, peculiarly valuable.

NORTH OF ENGLAND INSTITUTE

OF

MINING ENGINEERS.

GENERAL MEETING, THURSDAY, MARCH 7, 1861, IN THE ROOMS OF THE INSTITUTE, WESTGATE STREET, NEWCASTLE-UPON-TYNE.

NICHOLAS WOOD, ESQ., PRESIDENT OF THE INSTITUTE, IN THE CHAIR.

The SECRETARY having read the proceedings of the Council,

The following gentlemen were elected members:—Mr. Thomas Belt, Newcastle; Mr. John Muckle, Littletown Colliery; Mr. Wm. Lishman, Lumley Colliery, Fence Houses; and Mr. Alfred Hewlett, Ince Hall Coal and Cannel Works, Wigan, Lancashire.

The PRESIDENT called attention to M. Von Carnall's works, copies of which that gentleman had presented to the Institute; also to a set of Ordnance maps which had been purchased.

Mr. REID—The present of M. Von Carnall was accompanied by a note, which he would read, and which it would be well to have entered on the proceedings:—

"M. R. Von Carnall, in forwarding some publications of his for the Institute, begs to express his gratitude for the honour of being elected an honorary member, and to thank the members for vols. I. to V., which he has received, and which he considers well deserving of the acknowledgments of mining engineers, both at home and on the continent."

Referring to the papers which he sends, and which now lie on the table, he says:—

"The Geological Map of Upper Silesia is a 2nd edition. In comparing it with the first, which appeared in 1844, it has been thoroughly amended, partly in consequence of new discoveries, and partly to accord with observations made in the interim in other countries. The accompanying little book contains short explanations of the composition,

thickness, &c., of our formations. The metallic veins, or, more properly, bunches or sops of more or less variable thickness, and still more variable qualities and per centage, are, in general, closely connected with the dolomite of our Muschelkalk, and have a very peculiar character. A general synopsis of these beds I am now preparing, and, so soon as published, I will send a copy.

"A look into the map and accompanying section will show the whole extent of our coal measures; the most important part of which is represented by the large plan, consisting of twelve sheets, and six of vertical sections—the former on a scale of $\frac{1}{16000}$, the latter $\frac{1}{3200}$, which are on a larger scale than any other I am acquainted with.

"To give a general view of the whole, I add a geological sketch, on a scale of $\frac{1}{80000}$, with an accompanying explanatory volume.

"The aggregate thickness of *coal* is 300 feet, and, curious enough, it is everywhere at an attainable depth.

"The first three volumes of the Zeitschrift für das Berg Hütten und Salinen Wesen in dem Preussischen Staate are the only ones I have at my disposal, as I have given up the editorship, though my name appeared in the three ensuing volumes.

"Lastly, I add five small statistical pamphlets of the produce of all mines, smelting and salt works in Prussia, their value, and the number of the workmen employed during the last five years—the preceding five years being all to the found in the Zeitschrift."

It was then resolved that M. Von Carnall, Chief of the Prussian Mining Department, be thanked for his present of books, and that in return the three last volumes of the "Transactions" of the Institute be forwarded to him by the Secretary.

The PRESIDENT said, the first business would be, to make arrangements for holding the proposed meeting at Birmingham in July next. The Council had prepared resolutions and a form of circular, which he would read:—

[CIRCULAR.]

"*North of England Institute of Mining Engineers, Neville Hall, Newcastle-on-Tyne, March* 7, 1861.

"SIR,—I am requested to forward you the annexed resolution, appointing a Central Meeting of this Institute to be held at Birmingham on the 9th, 10th, and 11th of July next.

"It is expected that those members and honorary members will attend

on the occasion, whose distance from Newcastle precludes their being habitually present at the ordinary meetings.

"Particular attention is drawn to that portion of the resolution which relates to the reading of papers, and the exhibition of models of mining apparatus; and the Managing Committee will be glad to learn from you, on or before the 1st of May next, whether it be your wish to read a paper, or to exhibit such models; and if so, in connection with what subject, which may be either scientific or practical, it being the object of the Institute to admit of the fullest scope to any suggestion or discussion bearing upon the security of life or property in mines.

"The Managing Committee will be, of course, called upon to exercise a discretion in the choice of papers, for the obvious reason, that the limited term of the meeting will not admit of their being, probably, able to satisfy all the demands upon them; but this qualification is not applicable to models, nor can it be construed, for the reason assigned, as being prejudicial to the character of any paper that may be proposed, and which may be subsequently read, in the usual course, at the ordinary meetings of the Institute, if approved by the Council.

"A programme of proceedings will be sent you as soon as the Managing Committee have completed their arrangements, and, in the meantime, they will be glad to hear from you, as above mentioned, by address to the undersigned.

"The Managing Committee conclude by expressing their hope and confidence that this first Central Meeting of the Institute will, by the exertions of its ordinary and honorary members, be creditable to the Institute itself, and will also materially extend the sphere of its usefulness.

"I am, Sir,

"Your obedient Servant,

"THOMAS DOUBLEDAY, SECRETARY."

"RESOLUTIONS.

"That with the view of efficiently carrying out the objects of the Institute, which consists of members resident on the various coal fields of Great Britain, a First Central Meeting be held at Birmingham, on the 9th, 10th, and 11th July next, and that the Council of the Institute, with the addition of such gentlemen as the Council may nominate, connected with the Midland, Southern, and Western Mining Districts of the Kingdom (three being a quorum) be a Managing Committee for the purpose of making the requisite arrangements.

"That a circular be addressed to each member and honorary member, requesting his attendance, and also asking to be informed whether it be his wish to read a paper, or to exhibit models of mining apparatus, with a view, in the first instance, to the information of the Managing Committee, and to their selection of such papers as are conceived to be best adapted to the occasion, consistently with the limited period of three days, over which it is proposed the proceedings shall extend.

"That the Managing Committee be requested to take the entire subject into consideration, and to frame a programme, and report the result of their proceedings on this and other matters connected with the Central Meeting, at the general meeting of the Institute, which will be held on the 4th of April next."

Mr. Potter suggested that it would be desirable to add to the Committee the names of parties resident at Birmingham.

The President said, the whole subject of the arrangements would be laid before the Institute at the meeting in April.

Mr. Dunn—Would any inconvenience arise from delaying it another month?

The President said, the Committee ought to report the programme on the 4th of April. The time for sending in answers about papers might perhaps be extended beyond the 4th.

It was then resolved, "That the Committee report on the 4th of April; but that the time for receiving notices of papers to be read be extended to the 1st of May."

The President said, the next subject was with reference to the proposed Mining College in connection with the University of Durham. The establishment of a Mining College had been brought before the Institute on several occasions. They would have observed by the newspapers, that the question of the present state of the University had been brought before Parliament. The Home Secretary said it was intended to appoint a Commission of Inquiry as to whether any improvement could be made in the University as an academical institution. It had occurred to him (the President) that it might be desirable for the Institute to remind the Home Secretary of what had taken place in reference to the establishment of a Mining College last year, and to the promise he then made. He might mention that, last year a deputation went to the Home Secretary, in which Professor Chevallier represented the

University, the object of which was to induce the Government to take up the question as one of national importance. Sir G. C. Lewis, who was then Home Secretary, after hearing all the representations on the subject, promised to give the matter his serious consideration. Every person knew that meant, that it would be dropped altogether until something again occurred to bring it before the Government and the public. He thought it would be a good opportunity to remind Sir George Lewis of his promise; and perhaps the best mode of approaching that gentleman would be the presentation of a memorial from the Institute, requesting that, when the Commission was appointed, it should have instructions to investigate and consider the propriety of incorporating a Mining College with the University, and to provide the requisite funds. In order to ascertain what the feelings of the University were on the subject, he had recently had a conversation with Professor Chevallier, who stated that it would be strictly in accordance with the feelings of the University that, when the Commission met at Durham, the Institute should lay their case fully and completely before the Commissioners. He had drawn up a memorial to be presented to Sir George Lewis, asking him to give instructions to the Commissioners to take into consideration the question of the incorporation of a Mining College with the University. This had been laid before the Council, who ordered that it should be presented to this meeting, and he would now read it:—

"To the Right Honourable Sir George Cornewall Lewis, Bart., Secretary of State for the Home Department, &c.

"The Memorial of the Members of the Northern Institute of Mining Engineers,

"*Sheweth,*

"That your memorialists are members of the Northern Institute of Mining Engineers, most of them being practical managers of coal and other mines in different parts of the United Kingdom, in number two hundred and fifty-two members.

"That such Institution has now been established for upwards of eight years, the meetings being generally held monthly, in Newcastle-upon-Tyne, at which meetings scientific and practical papers on mining, and other subjects connected therewith, are read, discussed, and published.

"That the Institute have already published eight volumes of their 'Transactions,' copies of which are hereby presented to the Home

Office, and from which the description of the papers read, and the nature of the discussions at the meetings, will be seen.

"That the primary object of such Institution is to improve the scientific, practical, and economical management of mines, and particularly with regard to the diminution of accidents, and security of life of the persons employed.

"That, though the loss of life generally has, of late, been numerically diminished in proportion to the quantity of coals raised, your memorialists sincerely regret that very serious and great loss of life occasionally occurs.

"Your memorialists have long been of opinion, that the establishment of a Mining College, based on the instruction of pupils in the scientific and practical management of mines, in some central mining district of the kingdom, with district schools connected therewith, would be of essential service to the mining interests, and would be of the most essential service in the diminution of such deplorable accidents. And your memorialists beg your attention to those parts of the proceedings of the Institute which have relation thereto.

"Your memorialists beg particular attention to the proceedings of the Institute with reference to the establishment of an independent College at Newcastle-upon-Tyne, and the munificent offer of His Grace the Duke of Northumberland for the endowment of such a College.

"And your memorialists likewise beg reference to the proceedings of the Institute with regard to the incorporation of a Mining College with the University of Durham; also, the result of an interview of a deputation to the Government on such incorporation, at which interview the University was represented by Professor Chevallier, who expressed the readiness of the authorities of the University to forward the views of your memorialists, it being understood that the proposed Mining College, though connected with the University, is yet to exercise an independent action by means of its own governing body.

"Your memorialists have perceived, from the proceedings of Parliament, that it is proposed to appoint a Commission to inquire into the present state of efficiency of the Durham University as an academical institution of education, with a view of rendering the same more efficient and more generally useful as an institution for the instruction of youth.

"Your memorialists would further beg to point out that, should it ever be deemed advisable that the responsible managers of mines should be subjected to an examination, and that certificates of competency

should be given, the proposed College, together with the district schools connected therewith, and probably the inspectors of mines of the several districts, would form a system by which not only the principal or scientific, but also the subordinate, managers of mines might be subjected to an examination, and certificates given of their competency to undertake the onerous and responsible situations to which they might present themselves for appointment.

"Your memorialists, therefore, humbly beg, having reference to the proposed arrangements set forth in the negociations with the University of Durham, and to the importance, in a national point of view, of the establishment of a practical Mining College, that you would give instructions to the proposed Commissioners in such investigation, to take into consideration the propriety of incorporating with the University of Durham a College for the instruction of mining and manufacturing pupils, and of providing the requisite funds for that purpose.

"And your memorialists will ever pray, &c., &c.

(Signed) "NICHOLAS WOOD,

"President of the Northern Institute of Mining Engineers.

"*Northern Institute of Mining Engineers,*
Newcastle-on-Tyne, March 12, 1861."

The memorial was then unanimously adopted, and it was resolved that it be signed by the President on behalf of the meeting, and that it should, together with copies of the eight volumes of the Society's "Transactions," be presented to the Home Secretary.

The PRESIDENT said he had just received a communication which he was requested to lay before the meeting, viz., an offer made by Mr. Ogden, of Whitwell Colliery, to be one person out of ten to subscribe a thousand pounds, *i.e.*, £100 each for five years, making £5000, to be offered as a premium for the best mode of employing locomotive traction underground.

Mr. DUNN moved that the offer of Mr. Ogden be entered in to-day's proceedings.—Agreed to.

Mr. POTTER moved a vote of thanks to Mr. Ogden for his handsome offer, which was carried unanimously.

The PRESIDENT said, the next subject was the reading of a paper by himself on the Hetton Explosion. He thought it desirable, as the subject

was of very great importance, that the evidence given at the inquest bearing upon the cause of the accident and on the scientific enquiry should be given in full, and with the view of obtaining it as accurately as possible, he had got Mr. Maynard, the coroner, to give him a copy of the official minutes taken by himself at the inquest. The question was, whether these minutes should now be read. It had also been suggested that the evidence being very voluminous it might be undesirable to publish the whole, but that extracts might be given. On the other hand it was very desirable that all the facts should be before the public, and, therefore, there was some difficulty in abridging them. Some facts that might appear to some persons to be of no importance might be of importance to others. What he proposed was that Mr. Thos. John Taylor and himself should sit down and go through the whole of the evidence, and whilst they should make it as full as possible, they should, at the same time, strike out all extraneous matter, and so reduce it to moderate bounds. We could not take any general discussion of the paper to-day. It was a subject of great importance, and as it might be taken up at the meeting which it was intended to hold at Birmingham, it was desirable, in the first instance, to get in print the opinions of gentlemen who gave evidence at the inquest, the discussion could then be taken at the April or May adjourned meeting, and printed and circulated previous to the meeting at Birmingham, when the adjourned discussion might be taken. He (the President) after reading the paper, remarked that he had received a pamphlet published by the Manchester Geological Society, from which it appeared they had been discussing the subject at Manchester.

Mr. Bell said, if he was not out of order he would mention a circumstance which occurred to him after giving his evidence as to the cause of the accident. The difficulty they had in accounting for it was this; they attributed it to a coincidence of circumstances. But that was the thirty-fourth year in which the flue had been used, and there was the difficulty of specifying any reason why these same causes should not sooner have been coincidently brought together. In going into the flue, he had stated how he had found the damper. It was broken in two, one half was lying at the bottom, and the other was resting at the top, to which it had been drawn by the counterbalance. He could not help thinking that this damper had been in its place intact at the explosion, seeing that the explosion went through the furnace, and then blew down such inconsiderable work in front. Necessarily the first operation, as far as the timber was concerned, would have been to blow down this

diaphragm. This was not the case. The timber was placed as if it had been cut in two by a millwright. After giving his evidence, amongst other gentlemen, Mr. Reid had sent him some facts which had taken place in boiler explosions under circumstances where no gas could have been brought into operation, because they were above ground. There were frequent explosions in boilers of a certain construction. In one case it killed the fireman. This always took place immediately after the fireman opened the door to fire again. Having these facts in view, his impression was, that the damper, being made of cast iron, cracked, and as soon as the top was relieved of the lower portion, which kept it in its place, it went to the top. Instantly a very great influx of air took place over the fire place. This mixed with the gas in the flue, probably took fire, and caused the explosion. If this were so, it accounted for the abnormal state of things which, probably, never took place before in the history of this flue—the cracking of the damper, and letting in a great quantity of air. Perhaps the gentlemen taking part in this discussion might take this as an addendum to the evidence he had already given. He thought this would account for the explosion. He was quite of opinion that the quantity of gas and the conditions of the flue were such as would account for every appearance that was seen either by himself or others.

Mr. Reid said, the information he had given to Mr. Bell came from Mr. R. B. Longridge, of Manchester.

Mr. Atkinson—Mr. Longridge stated the same thing in the Manchester discussion.

Mr. Bell—Mr. Forster told me that one of the engineers who was down the colliery afterwards, said there were traces of an old crack across the damper.

The President—He never heard of that. We had the damper examined and we could not see that.

Mr. G. B. Forster said John Hedley, the engineer of South Hetton, had informed him of it.

The President—At the meeting at Manchester, at which Mr. Longridge was present, he said, "I know a similar case of an explosion that occurred with a multitubular boiler, and there was also a flue underneath the boiler, with a damper in front. The gentleman to whom the mill belonged went to the back end and opened the smoke-box door to show a friend how low the temperature was in the smoke-box, and while he was there the fireman, not knowing of his presence, threw on his coal

as usual, and went to the next boiler; but observing that his damper, which worked on a swivel, had shut, and that the smoke and gas were coming out at the fire door, he stepped back and turned the damper to give the draught as usual." He then states, that an explosion took place which burnt both the gentlemen very severely. The Chairman asked him if these were the only instances he knew, and he replied, "I know another instance of an ordinary two-flue boiler; but then they were making use of sawdust as well, and the gas got mixed with it." At the next meeting, when we come to discuss the subject, any gentleman who has heard of any cases would, he trusted, bring them forward.

Mr. ATKINSON—There was a case at Thursdale Colliery.

Mr. COCHRANE said it blew away the front of the brick work. He would get the particulars.

Mr. REID said, he had heard of one or two more in the Glasgow district.

The PRESIDENT said, Mr. Daglish had letters from various parties on the subject. If any gentleman would send him any facts he would incorporate them with the proceedings.

Mr. Daglish's paper, on "The Construction of Ventilating Furnaces," was then read by Mr. SOUTHERN, Mr. Daglish himself not being present.

The meeting then broke up.

ON THE

EXPLOSION AT HETTON COLLIERY,

ON THE 20TH DAY OF DECEMBER, 1860.

By Mr. NICHOLAS WOOD.

On the 20th day of December, 1860, at about half-past 8 o'clock in the evening, an explosion took place in the East and West Minor Pits, which was attended with the most serious results, and by which twenty-two persons, nine horses, and fifty-six ponies were killed, and considerable damage done to the pits. The explosion took place in the immediate vicinity of the downcast pit, and as it was considered quite impossible that any explosive gas could have occurred in that locality, it was at first thought to have occurred by an explosion of one of the steam engine boilers—there being three steam engines, and three high-pressure steam boilers near the bottom of these shafts.

When access was obtained to the bottom of the pit, as will hereafter be explained, it was ascertained that the explosion had taken place in the boiler flues of one of the engines, called Davison's engine; that it had blown the flues to atoms where the explosion had at first occurred; that it had then blown down a crossing or archway over the main wagonway (about eighty yards from the centre of the explosion), and had then spread right and left from such crossing, one current passing to the left along the main west wagonway to the shaft, where it had blown seventeen fathoms of the brattice out of the shaft, and had then proceeded into the west way, where, at a distance of 800 yards from the shaft, it had killed several men; at the same time, the other current had passed along the east wagonway, and, at about the same distance, had killed four men—the effects of the explosion being, however, felt at a distance of upwards of a mile from the centre of the explosion, in both directions. In a north and south direction, the main ways being at right

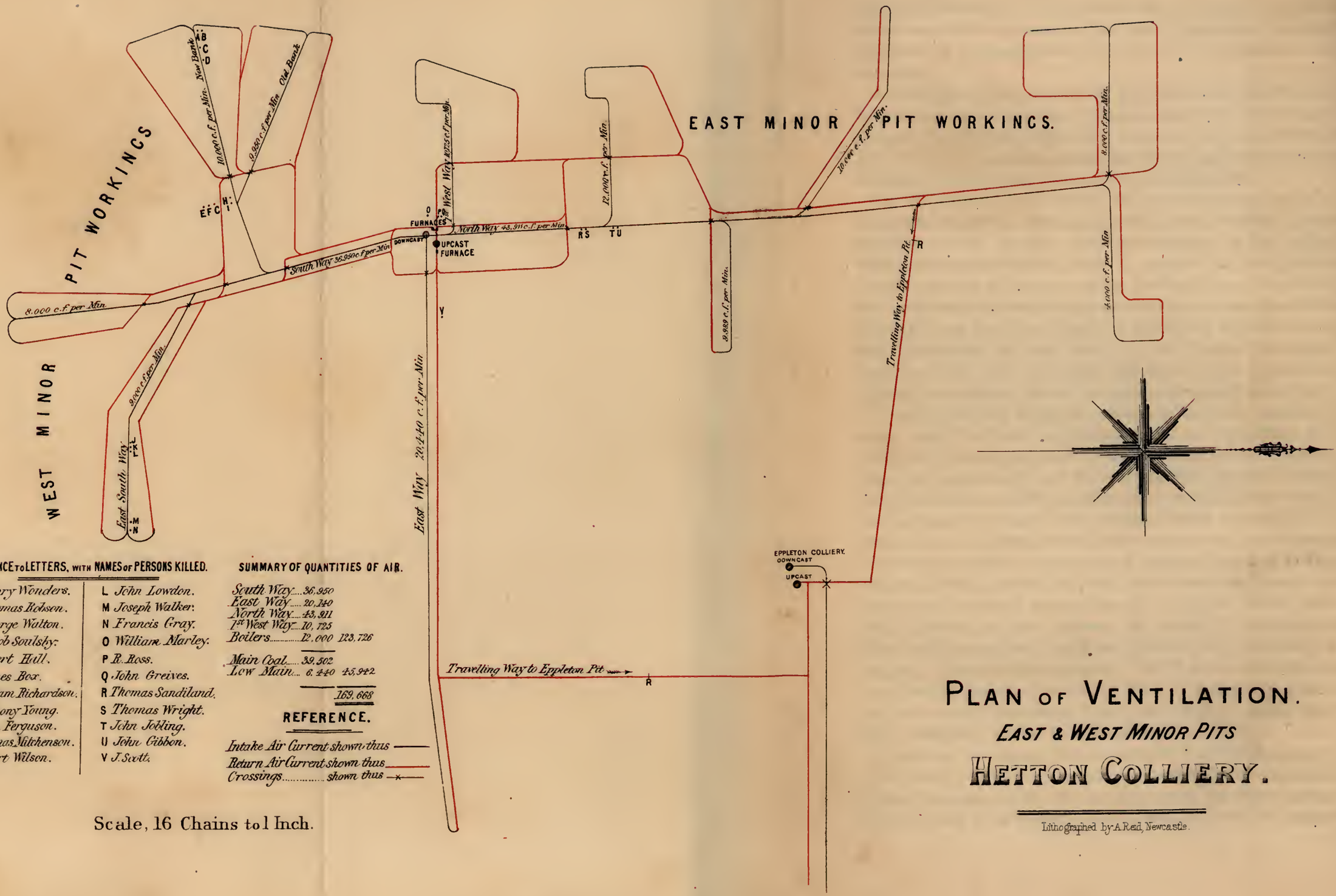
angles to the direction of the explosion from the crossing, though the effects were felt for upwards of 1000 yards, yet the force was much diminished by its passage around the angles of the entrances into the main roads.

A conclusion was soon arrived at by the parties in charge of the mine, that the explosion could not have been occasioned by the ordinary gas of the mine (a conclusion corroborated by subsequent inquiries), but that it had occurred by an explosion of some description of gas generated within the engine flues of Davison's engine in the East Minor Pit.

The circumstances and results of this explosion being of an almost unexampled character, and being likewise of so important a nature regarding the risk attendant upon the employment of fire engines, boilers, and flues underground, render it advisable that every publicity should be given to all the circumstances attending such an event, for the purpose of clearly and unequivocally ascertaining and considering all the facts of the case, that I have thought it of sufficient importance to lay before the Institute the result of all that took place at the coroner's inquest, and any other facts which such inquiry elicited, and which appeared to me to bear upon the investigation of so important an inquiry.

I may premise that, finding the explosion to have been occasioned by causes which were most unprecedented, and so very difficult to be accounted for, and of so mysterious a nature, I suggested that the inquiry before the coroner should be of the most searching character—that all the evidence which could by possibility throw any light upon so intricate a subject should be obtained; and, therefore, besides examining all the witnesses usual on ordinary occasions of explosions, viz., of the workmen in the mine at the time, of the persons in practical charge of the mine when the accident occurred, and of the viewer under whose direction the underground operations were conducted, I called in several professional gentlemen of other collieries, who assisted in recovering the bodies, and who rendered most efficient assistance on so melancholy an occasion, I also obtained the evidence of two of the most scientific and manufacturing chemists of the district, Mr. I. L. Bell and Dr. Richardson, with a view of ascertaining if they could, by their chemical knowledge, satisfactorily account for so extraordinary an explosion.

In soliciting the attention of the Institute to so important an inquiry, it will, perhaps, be the most advisable mode, and that which will promote the most impartial inquiry, if I lay before them the official evidence adduced on oath at the inquest, which I am enabled to do by the kind-



REFERENCE to LETTERS, with NAMES of PERSONS KILLED.

A Henry Wonders.	L John Lowdon.
B Thomas Robson.	M Joseph Walker.
C George Walton.	N Francis Gray.
D Jacob Soulsby.	O William Marley.
E Robert Hull.	P R. Ross.
F James Box.	Q John Greives.
G William Richardson.	R Thomas Sandiland.
H Anthony Young.	S Thomas Wright.
I John Ferguson.	T John Jobling.
J Thomas Mitchenson.	U John Gibbon.
K Robert Wilson.	V J. Scott.

SUMMARY OF QUANTITIES OF AIR.

South Way	36,950	
East Way	20,240	
North Way	43,911	
1st West Way	10,725	
Boilers	12,000	123,726
Main Coal	39,502	
Low Main	6,240	45,942
		169,668

REFERENCE.

Intake Air Current shown thus ——
Return Air Current shown thus ——
Crossings ..... shown thus —×—

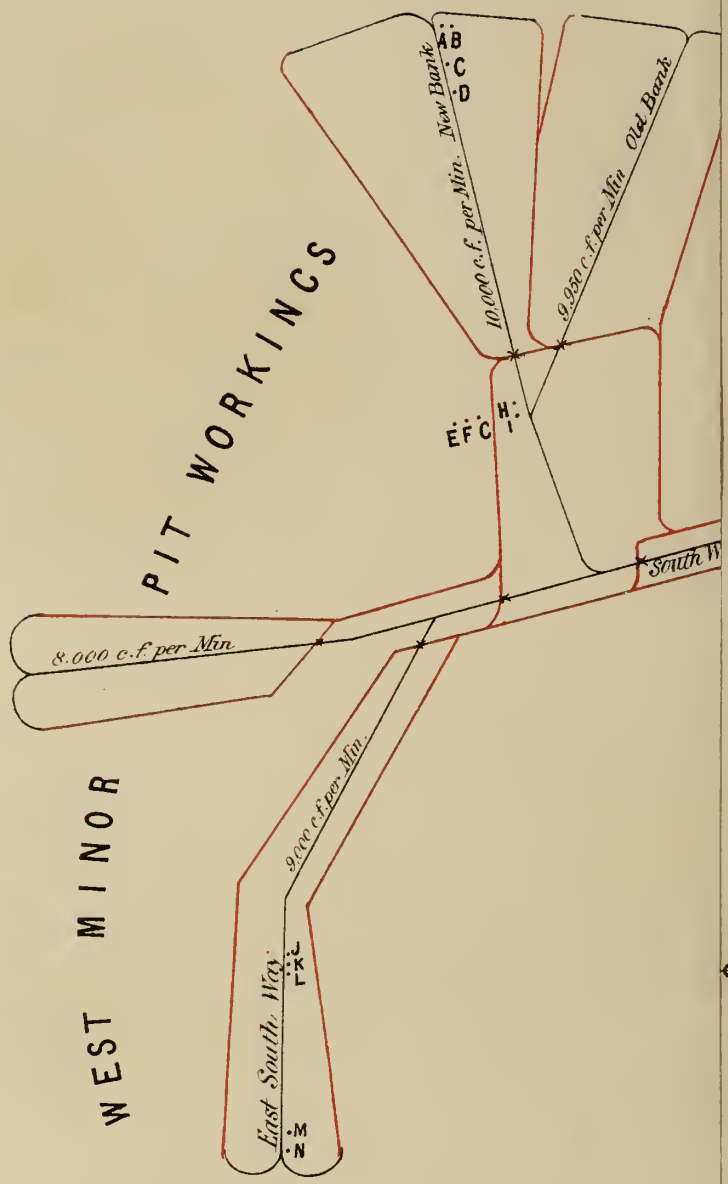
Scale, 16 Chains to 1 Inch.

PLAN of VENTILATION.

EAST & WEST MINOR PITS

HETTON COLLIERY.

Lithographed by A. Reid, Newcastle.



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H *Anthony Young.*	S *Thomas Wright.*
I *John Ferguson.*	T *John Jobling.*
J *Thomas Mitchenson.*	U *John Gibbon.*
K *Robert Wilson.*	V *J. Scott.*

SUMMARY OF QUA

South Way	36,9
East Way	20,1
North Way	43,9
1st West Way	10,1
Boilers	12,0
Main Coal	39,5
Low Main	6,4

ON.

REFER

Intake Air Curren
Return Air Curren
Crossings

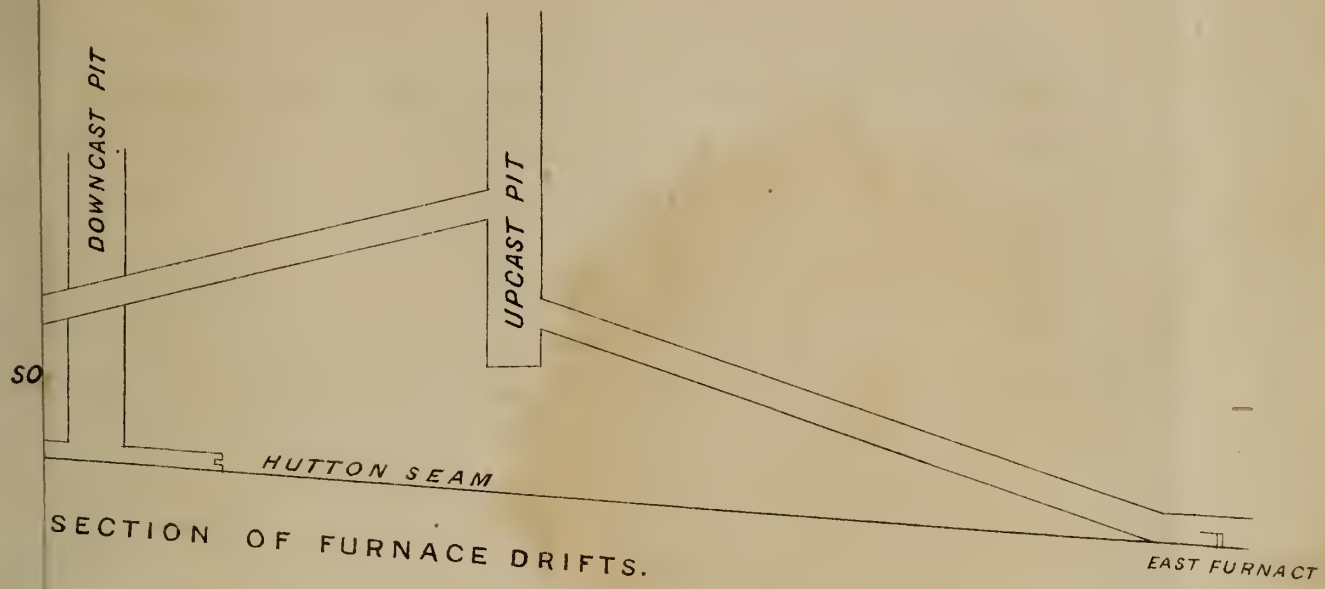
Scale, 16 Chains to 1 Inch.

ness of the coroner, T. C. Maynard, Esq., who has forwarded to me a copy of the depositions taken by him on that occasion. In order, however, to make that evidence more intelligible, I have annexed copies of some plans exhibited at the inquest, explanatory of, and showing the situation of the pits, the direction and extent of the different main roads and air courses, and the quantity of air circulating in the different splits of the East and West Minor Pits, which were the pits in which the explosion occurred. I have also added two plans, on a larger scale, showing the underground furnaces, and the different air courses around the downcast and upcast shafts—the position of the different engines near the bottom of the pits—and of the boilers and flues, particularly the flue in which the explosion occurred; showing the state of the flues previously to and at the time of the explosion, and the state in which they were found after the explosion had taken place; together with plans of the damper of the boiler, and the fire place from which it is supposed the explosion originated. These will, I trust, enable the members of the Institute to more clearly understand the evidence, and to investigate the causes which led to such a lamentable accident.

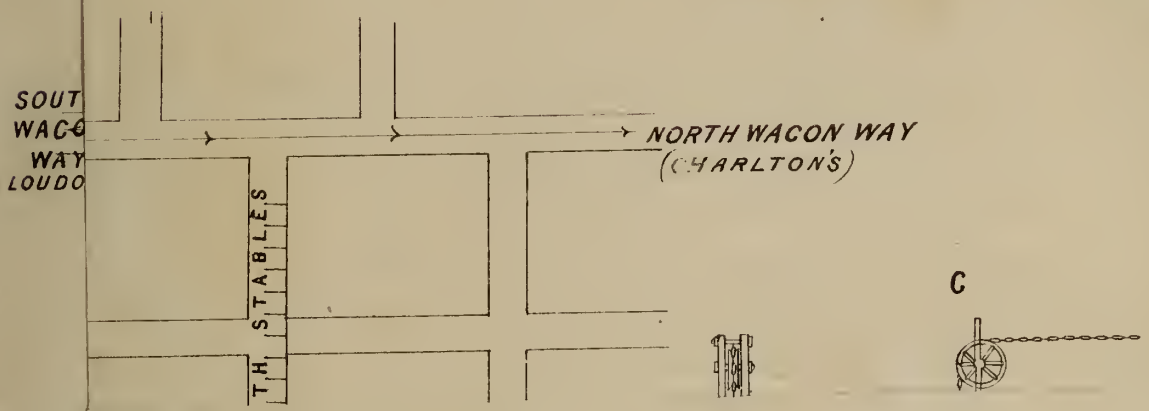
Plan No. I. shows the general ventilation of the two pits in which the explosion occurred, with the main air courses and splits of the air, on which is marked the quantity of air passing along these splits, and into the different districts of workings immediately preceding the explosion. It may be explained, that in this portion of the Hetton Collieries there are two perfectly distinct and independent shafts or pits; one called the East and West Minor Pit, which is marked on the plan as the *downcast*, and which are denominated the *Lyons Pits or Colliery;* and the other, which is called the Blossom Pit, marked on the plan as the *upcast*, the latter pit not being sunk below the furnace drifts (coloured yellow), which, as shown in plans II. and III., enter it on both sides; therefore it crosses the roads from the downcast pits from twenty to thirty feet above them. The reason why the downcast is termed the East and West Minor Pits is, that the shaft is divided by a partition or brattice, on each side of which are drawing apparatus by which the coals of two pits workings—the East Minor Pit workings, and the West Minor Pit workings—are drawn to bank. The airways, or main roads along which the intake currents pass, are shown in black, and the return air courses are shown in red lines, and the quantity of air passing is shown in cubic feet per minute. There are, as shown on the plan, two travelling roads to the *Eppleton Pits or Colliery*, another division of the colliery, and at which there are separate

and independent downcast and upcast shafts. The communication is closed by double doors, and these roads are only used for the purpose of travelling between the two collieries, and which, on this occasion, were found of great utility, as will be seen by the evidence. There is also another section of the colliery, called the *Elemore Pits or Colliery*, at which there are also separate downcast and upcast pits; but there are no travelling roads or communication between the Elemore, and the Lyons, or Eppleton Pits.

Plan No. II. shows the position of the two Lyons Pits, the downcast or East and West Minor Shafts, and the upcast or Blossom Pit, with the furnaces, viz., the east furnace, and the west furnace, and the drifts leading from them to the upcast shaft having a rise of about thirty feet. The positions of the several engines are also shown, and of the boilers; the direction of the steam pipes leading from the boilers to the engines being shown by black lines, and of the exhaust pipes by red lines. All the boilers are placed upon the level of the Hutton Seam, or of the bottom of the downcast shaft; the flues from Davison's engine passing across the main road near the Albert engine to the two furnaces, where it enters the furnace drift to the upcast shaft. The flue of the two boilers for the active and Victoria engines pass up a staple, shown on the plan, near the boilers into the furnace drift, which is there about twenty feet above the level of the boilers and downcast drifts. The section A, A, shows the inclination of the furnace drifts from the furnaces (which are on a level with the downcast shaft) to the bottom of the upcast shaft. The longitudinal section, on a large scale, showing the inclination from the boiler of Davison's engine to the furnace drift at the junction of the two west furnaces. This plan also shows the position of the stables, which were set on fire by the explosion; and also the route of the ventilation at and immediately preceding the explosion, the black lines showing the ingoing direction of the air from the downcast shaft, and the red lines the return currents from the different districts of workings to the furnaces and upcast shaft. Upon this plan, showing the longitudinal section of the flues from the boiler of Davison's engine to the bottom of the furnace drift at F, is likewise shown cross sections at A, B, and C, D. It will be seen by these that nearly up to the crossing of the main wagon-way, at X, the flue is double, with a passage road, *c*, *c*, above the flues, *a*, *b*, *a*, along the middle of which the smoke from the boiler passed, and that beyond and at the crossing the centre flue, *b*, along which such heated air passed, was of a larger area than between the boiler and the



SECTION OF FURNACE DRIFTS.



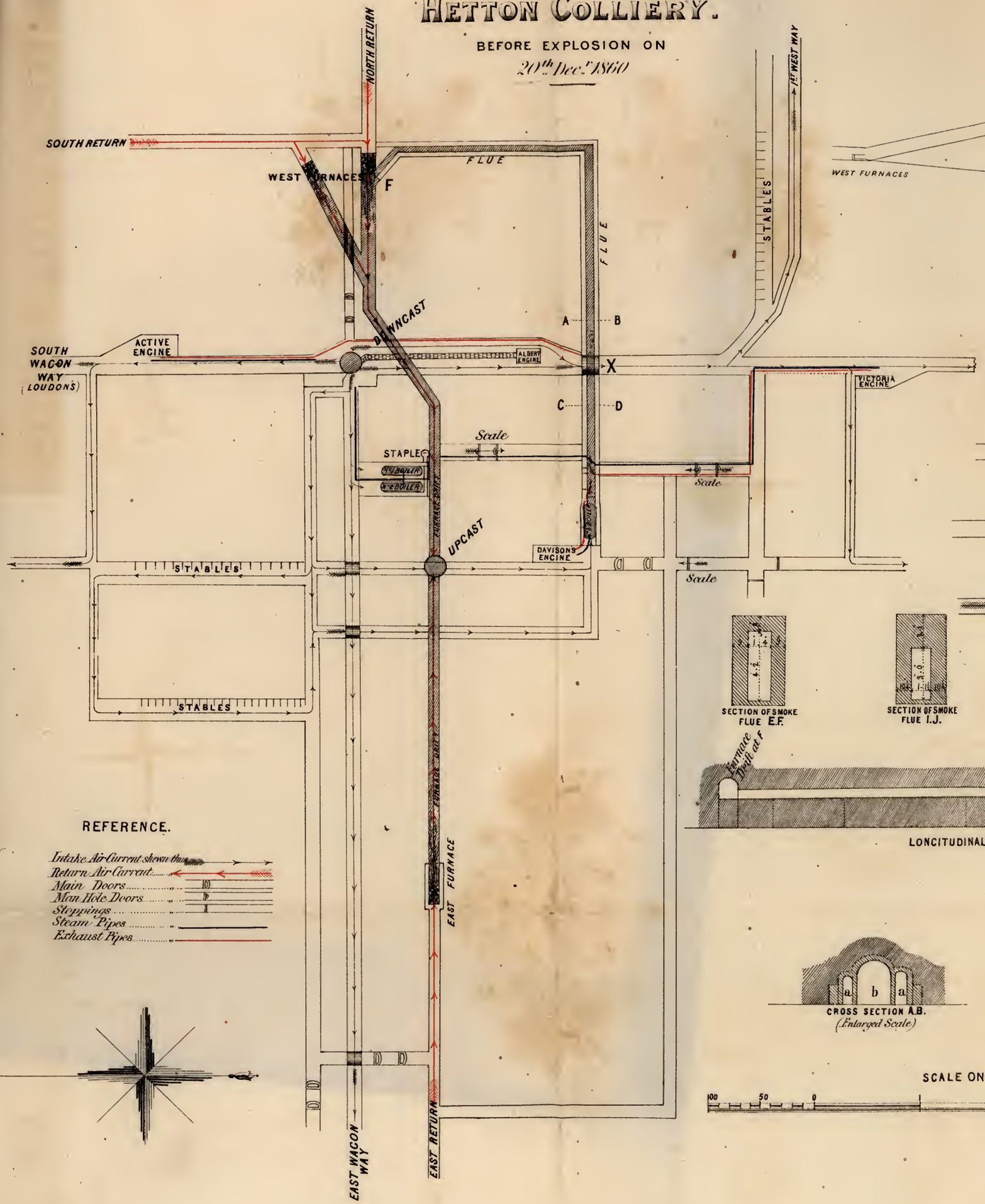
PLANS OF BOILERS, FLUE, FURNACES &c.

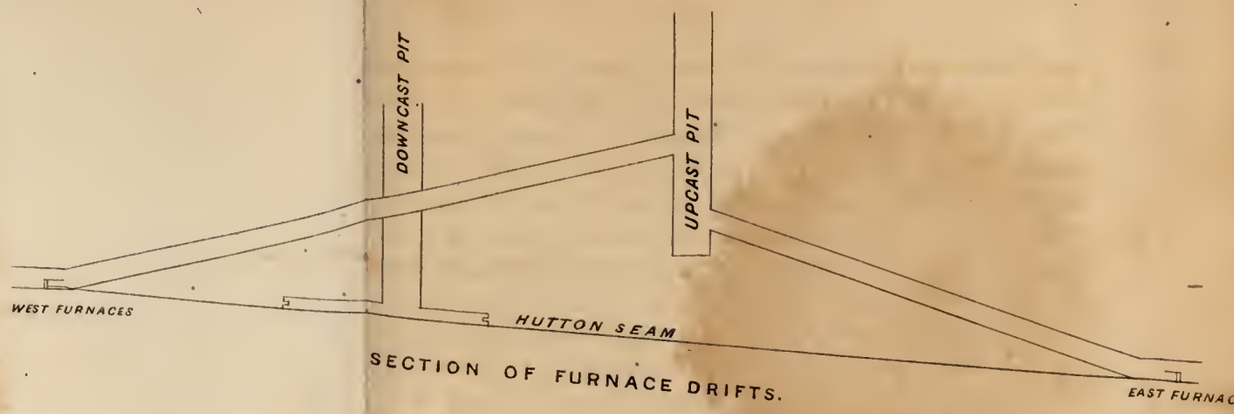
EAST & WEST MINOR PITS

HETTON COLLIERY.

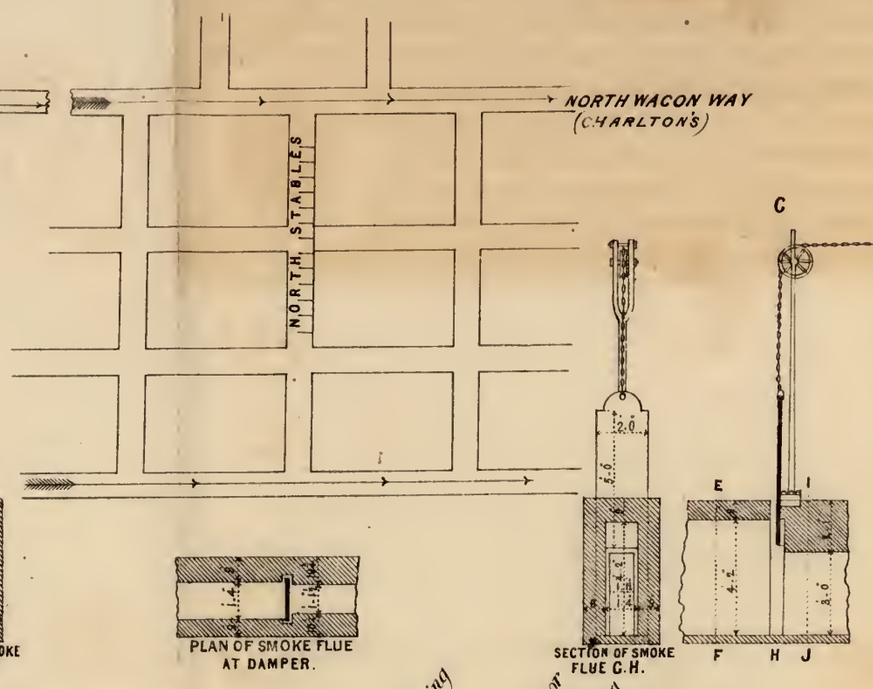
BEFORE EXPLOSION ON

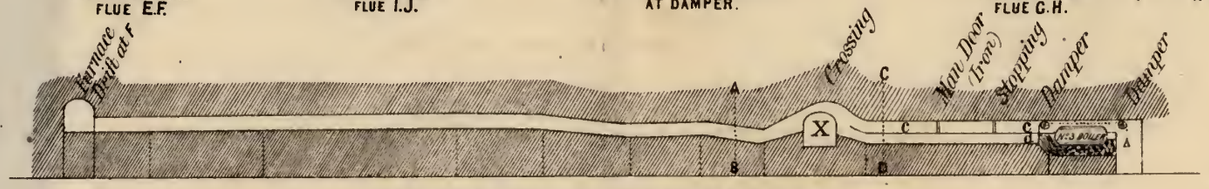
20th Dec.r 1860





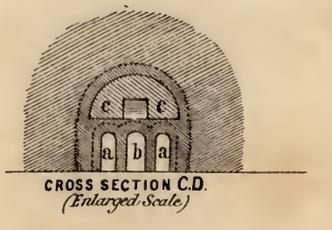
SECTION OF FURNACE DRIFTS.





LONGITUDINAL SECTION OF FLUE ONE CHAIN PER INCH.

CROSS SECTION A.B.
(Enlarged Scale)



CROSS SECTION C.D.
(Enlarged Scale)

REFERENCE.

Intake Air Current shewn thus
Return Air Current „
Main Doors „ D
Man Hole Doors „ P
Stoppings „
Steam Pipes „
Exhaust Pipes „

SCALE ONE CHAIN PER INCH.

100 50 0 1 2 3 4 5 CHAINS.

(Proceedings N° of E. I of M.E. 1860.)

Lithographed by A Reid, Newcastle

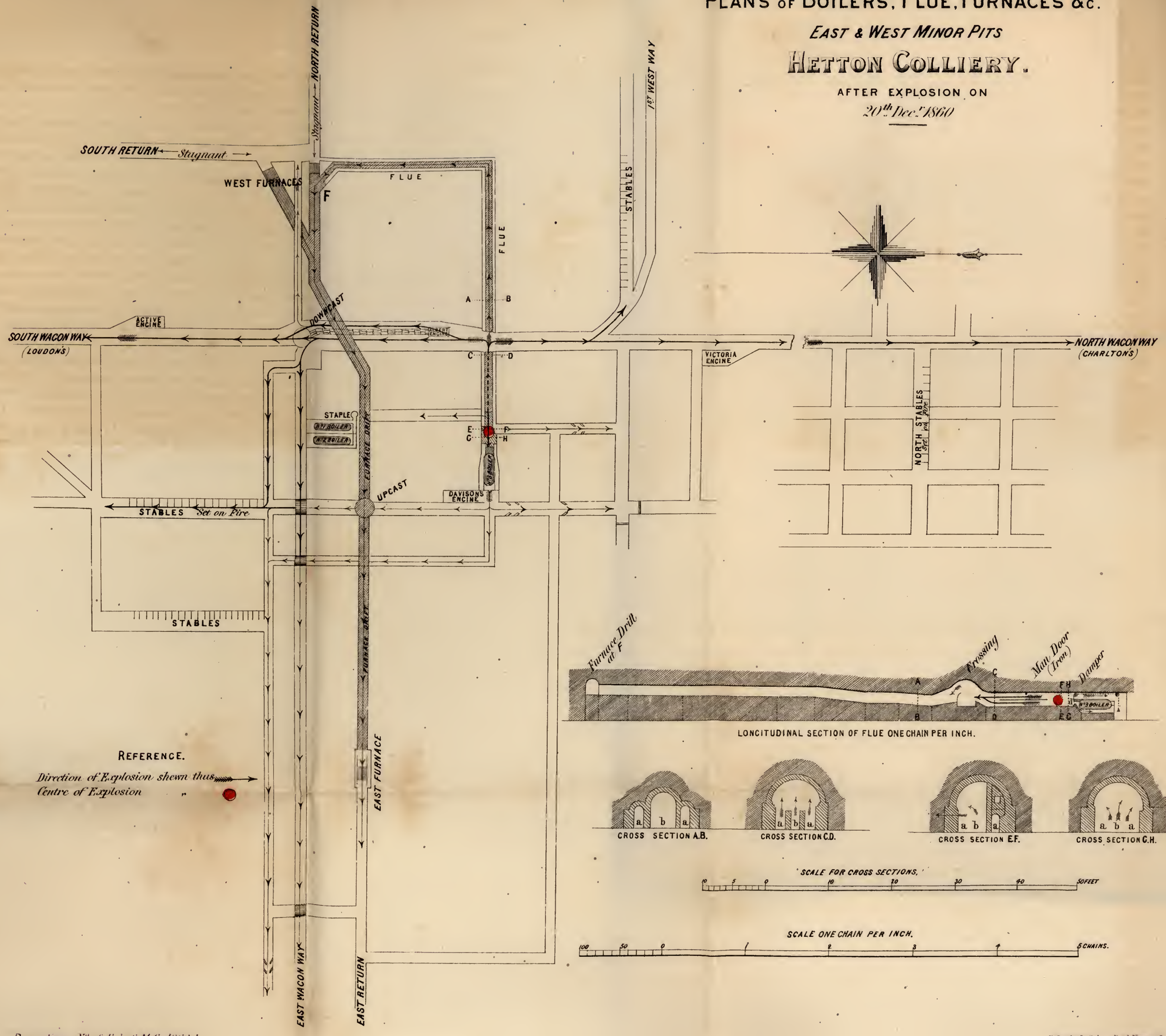
PLANS OF BOILERS, FLUE, FURNACES &c.

EAST & WEST MINOR PITS

HETTON COLLIERY.

AFTER EXPLOSION ON

20th Dec.r 1860



REFERENCE.

Direction of Explosion shewn thus →

Centre of Explosion ●

LONGITUDINAL SECTION OF FLUE ONE CHAIN PER INCH.

CROSS SECTION A.B. CROSS SECTION C.D. CROSS SECTION E.F. CROSS SECTION G.H.

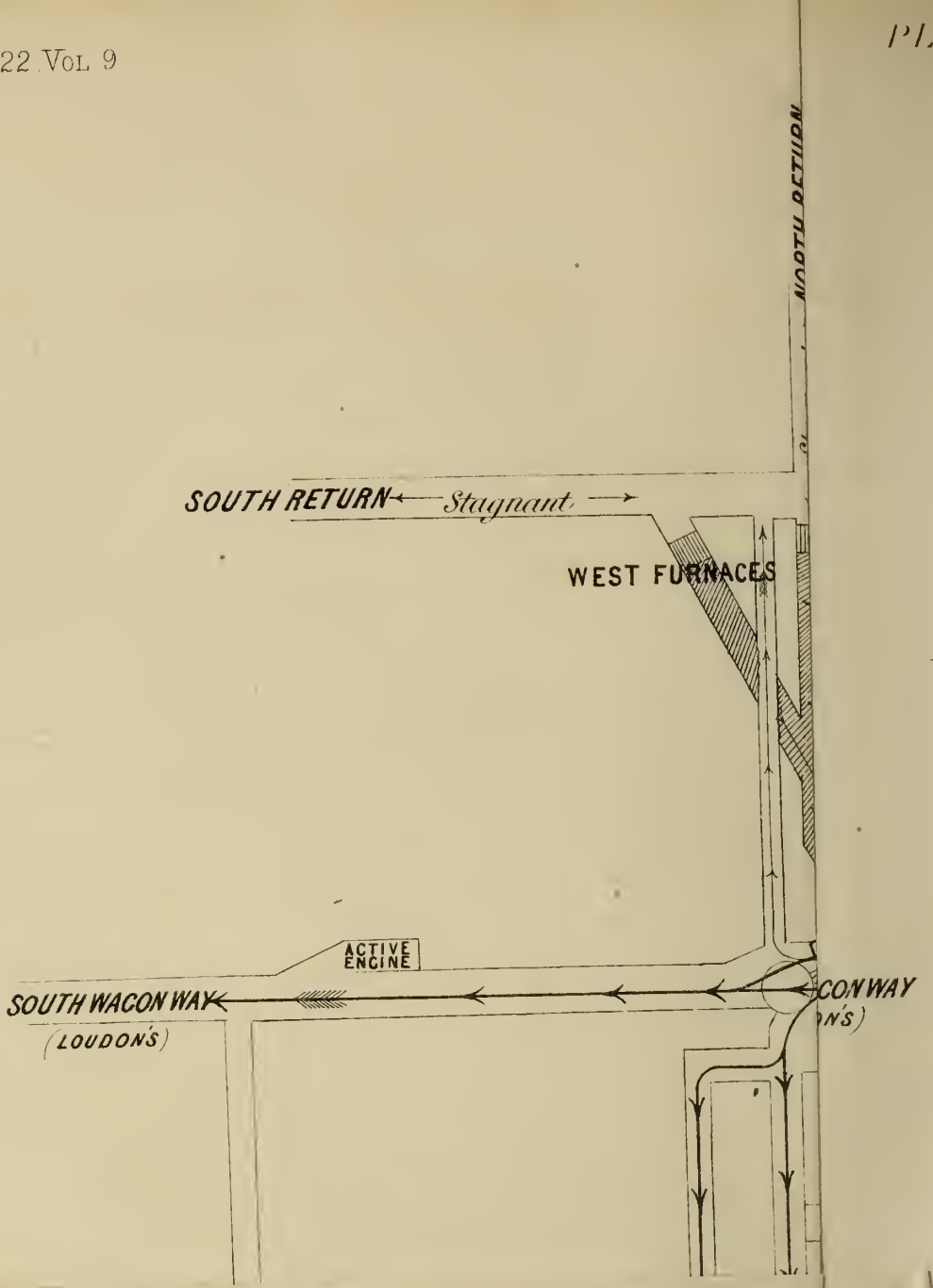
SCALE FOR CROSS SECTIONS,

10 5 0 10 20 30 40 50 FEET

SCALE ONE CHAIN PER INCH.

100 50 0 1 2 3 4 5 CHAINS.

Lithographed by A.Reid, Newcastle.


SOUTH RETURN
Stagnant
WEST FURNACES
ACTIVE ENGINE
SOUTH WACONWAY
(LOUDON'S)
CONWAY

crossing. The two smaller flues, *a*, *a*, were travelling roads, along which a considerable current passed to prevent the heat of the centre flue from setting fire to the coal.

Plan No. III. shows the state of the flues, crossings, &c., after the explosion, and the direction of the blast or explosion as adduced by the evidence, or shown by the effects of the explosion on the doors and passages around the shaft. It is unnecessary for me to give any detailed description, in this place, as it could only be a repetition of the evidence given at the inquest. I prefer that these particulars, and the effects of the explosion, should be given by the persons examined, than that it should be given by me at second hand; and that any conclusion which may be drawn from the evidence, or other details or particulars, should result from a free and unbiassed discussion by the members of the Institute, rather than from any observations of mine, except so far as I may deem it necessary to offer any opinion at such discussion. I shall, therefore, only give such explanation as may be necessary to make the plans clear and intelligible. It will be seen that plan III. is a perfect copy of plan II., except as altered to show the state of things after the explosion, and the addition of the two sections of the flues at E, F, and G, H, to show the effect of the explosion on the flues at these places. It will be seen that the darts on the plan are made to proceed from the red mark through E, F, on the plan, from whence, as a centre, the explosion proceeded in all directions; and the thickness of the lines are made to show, in some degree, approximately, the intensity of the explosion at the several places, and in the different directions.

Plan No. II. shows different plans of the flues and damper. From these it will be seen that the dimensions of the flue next the boiler is three feet by thirteen and a half inches up to the damper, and four feet two inches by sixteen inches beyond the damper. The damper works in a recess in the brick work, not in a metal frame. This recess is three inches in width, and three inches in depth all around the flue, the damper working up and down within such recess, in the usual manner, by a balance weight, working over a pulley, the weight working up and down near the engine fire. The damper was five feet in height and two feet in width, and half an inch in thickness. On the top of the flues, and of the recess in which the damper worked, was an iron plate, leaving an inch in width to steady the damper in working up and down within the recess, as shown in the plan.

It was given in evidence that the damper, when the fire was damped,

at five o'clock on the evening of the accident, was left about one and a half inch from being shut, this would give an opening of thirty-six square inches; and supposing only three-eighths of an inch opening into the flue around the damper within the recess would give about forty-four inches opening, making about seventy square inches through which the air would pass into the flue when the fire was damped. I have ascertained, by experiments made recently, that the velocity with which the air passes through the opening of the damper with seventy square inches of area is sixty-six feet per second, consequently, if there were seventy square inches of opening into the flue at the time of the explosion, or during the time whilst the fire was damped, there would be about 2000 cubic feet of air passing into the flue per minute.

I now proceed to give the evidence as adduced at the Inquest, so far as it bears upon the enquiry before the Institute, and leave the investigation to the members without comment.

THE INQUEST.

Edward Wailes Hall—I am master shifter for the three pits at Hetton Colliery. On Thursday night last, about half-past eight o'clock, the head keeper came to me and informed me something serious had happened at the East and West Minor Pits. I went to the pits, and found there was no means of getting down. I then proceeded to the Downs Pit, and went down it, and proceeded in a westerly direction to the East Minor Pit. When I came to the wagonway, I found the timber all blown out, and several falls from the roof in the way. I got over a very large fall, but the after-damp prevented me going further. The paper writing now given in by me is a correct list of all the men who have been killed in the pit. (See list on plan No. I.)

George Lowden—I am overman of the West Minor Pit, in which, on the 20th December last, the explosion took place. It is my duty to examine the workings before the men go in to their work. I went down on that day at twenty minutes past two o'clock in the morning. It is my duty to fix the places where the men coming down were to work. I had charge of the men and boys in the south way and at its extremity. They commenced working about half-past five o'clock, and the explosion took place between eight and nine o'clock in the evening. They were all killed. They were found in the main way. I left the pit that morning at eight o'clock, and was in my own house at the time of the explosion. Before I placed the men, I examined their places about

half-past three o'clock that morning, and found no gas. I came out by the return to the furnace, and found the return free from gas. I had no charge of any other part of the mine. I have been down since the explosion, and my opinion is, that it has gone from the flues. I think so, because the injury done spreads from that place both north and south. I have had charge of the West Minor Pit for the last thirteen years. I have not seen any gas where these men were working for three or four months. It might be some time before that I saw gas, but it was in the west way from the furnace. The ventilation was going all right when I left that morning. If the ventilation was all right when the explosion took place, I do not think it possible for gas to have come from these places and explode where it did. I could tell by passing along that the ventilation was all right. When I came up, the portion of the pit that I had charge of would be taken charge of by Robert Young. That is the whole of the West Minor Pit. When I saw the gas some months ago, it was in the west of the south way, in the pillar workings. The return from that portion of the workings does not go near the flues I have named; it goes to the two furnaces. There has been no explosion in that part of the pit where the gas was seen. There has been no gas seen by me in the neighbourhood of the flues. The gas which I saw was north of the places where the men were working, and if the ventilation was perfect there could be no communication between that place and where the men were working. The men worked with locked Davy-lamps. I had no fear of their working with naked candles when I left. I found five of the bodies on the 22nd day of December last. I found Robert Hall, James Box, and William Richardson in the return on the south side of the main way. They had not been injured by the force of the explosion, but had died from the effects of after-damp. I also found the bodies of Anthony Young and John Ferguson in the main way, rather beyond the bottom of the new bank from the shaft. They had been killed by the force of the explosion, I think near 600 yards from the furnaces. These five men were nearly all together. On the morning of the explosion I came out along the return, about 500 yards from the shaft, and when I came to the furnace I went into the north-west return of the two furnaces, and found no gas whatever. I found no tail or cap upon the flame of my lamp, nor any indications of gas in the places I examined. It was my duty to examine, and I did so, and found no indication whatever of gas. From the time I went in until the men

came down, I was employed in examining the workings, and had sufficient time to examine them carefully, which I did.

Robert Young, back-overman—I was down the West Minor Pit at nine o'clock in the morning of the day on which the explosion took place. The pit was in my charge until five o'clock in the afternoon. There was good ventilation the whole of the time. I cannot tell the quantity of air circulating, I considered there was sufficient for the safety of the men. I examined the water gauge, which tells the strength of the ventilation; it was standing at one inch and six-tenths at twenty minutes before five o'clock. There was no accumulation of gas or foulness in any part of the pit whilst in my charge. The ventilation was perfect up to the time when I left. I examined the goaves as I went round, and found they were not giving off any gas. Between the time I left and the time of the explosion I do not think gas could have accumulated and been carried to the flues. If there had been gas, whilst the ventilation was perfect it was not possible for it to have got to the flues. I have been down the pit every day since, and have seen the damage done, and I think the explosion took place in the flues, but cannot say what was the cause of it. I should say gas had caused it. I cannot form any opinion how the gas got there. The last time I saw gas at the edges of the goaves will be some months since, but I cannot say exactly. There has never lately been any cap or tail on my lamp in any portion of the workings. When the furnace was out there was a great difference in the ventilation, but there was no gas. There was a little fire in the two west furnaces when the other was not in use. No gas could have come from the Low Main to cause this explosion as there was so much air in the pit it would destroy it.

Thomas Smith—I am master shifter under Hall. On the 20th of December last, I went down the East Minor Pit at half-past five o'clock at night, to examine the lamps, lock them, and place the men. I examined the lamp of every man working in the pit that night whom I had under my care, and found their lamps all right. Lowden had five of the men in his charge. I placed four men, viz., Thomas Sandilands and Thomas Wright on the north way, about 500 or 600 yards from the downcast shaft, and John Jopling and John Gibbon, also on the same way, about 200 yards further in. I placed no more men in that district. I placed three men and a boy, viz., William Smith, Robert Gardiner, William Gardiner, and William Newman, in the east way, about 800 yards from the shaft. They got out alive. I placed George Gleghorn,

and Bond, William Anderson, Joseph Scott, and Richard Proud, a boy, in the same way, further in—600 or 700 yards further in than the Gardiners. I also placed Ralph Hope and Robert Simpson in the same way, but in a different direction. These were all saved but Joseph Scott. These are all the men I placed in the East Minor Pit. In the West Minor I placed, on the south side, John Ferguson and Anthony Young on the main way, near the bottom of the new bank. I also placed William Richardson, Robert Hall, and James Box, through the separation door into the return. I placed Thomas Mitcheson, John Lowden, and Robert Wilson in the east south way. They would be about 1000 yards from the shaft. I had not examined the workings of the pit previous to setting the men to work. It was not my duty. After I had placed the other men, I went north with the four men that went north. In setting them to work, I had only to pass the downcast shaft. There was no indication of gas in any of the places where I placed the men. I was in the pit when the explosion took place, 800 yards down the east bank. I was blown away by the explosion. It came from the west of where I was. As soon as I gathered myself together, I put up my hand to see how the ventilation was, and which way the air was going, and found it was going west. That was the wrong way. In less than a minute I found the air going in the right direction. I told the men I had placed in the east way to reconcile themselves. I got them all gathered together, and some of them told me they could not get up the engine bank for smoke. We then went up to the north return, and when we came to the tunnel that crosses the east wagonway, I told the men to take hold of jackets, and I went first, and proceeded to the downcast shaft of the East Minor Pit. When I got to the downcast shaft I found the furnaceman, and I then looked about and found the pit all blown to bits about there. I then went round to the West Minor shaft, accompanied by some of the men, and found all was blown to bits there also. Finding this, I then proceeded north, to make my road to Eppleton Pit. We proceeded about 300 yards north of the East Minor Pit, when we found the after-damp. We were obliged to return to the West Minor Pit, and remained there until seven o'clock next morning, when some deputies arrived. We then proceeded down the east way, and so to Eppleton Pit, and were all drawn safe to bank, except Scott and Hope, who had left us, and proceeded in another direction, the former being lost. My cabin is about 100 yards north from the furnaces, and I am down there every night, and near to the furnaces. I had

never noticed any gas in the part I had charge of, nor near the furnaces. I cannot tell the quantity of air circulating at the time of the explosion; but the air was good. I had no fear at all of any explosion taking place. I have been down six days since the explosion, working. I have examined about the shaft, and she has gone inbye all over. It would require the explosion of a large quantity of gas to cause the damage I saw. I can form no opinion where that gas came from. I do not think so large a quantity of gas could accumulate from the inbye workings of the pit without my knowledge. Open lights were used at the stables. In my opinion, it was quite safe to use candles. It is the first air from the downcast that goes to the stables. I have no idea where the gas came from that caused the explosion. I cannot say whether so large a quantity of gas could be generated in the boiler fires. There is an upper seam in the shaft, but it is not possible for it to have come from there. I am aware it has come from the neighbourhood of the shaft, but from where I cannot form an opinion. The air currents were as usual when I placed the men. The place I was standing in, when blown down, might be seven feet and a half by ten feet, and I was blown with violence about four or five yards: All the men, except three at the south separation door, were in the main intake. The boiler fire was fed with fresh air. If the foul air had come away from the west broken, it could not have got into the engine chimney, and no other foul return could have got from any other part of the pit to the engine chimney. I am quite satisfied that the explosion took place near the shaft. I think there was a sufficient quantity of air circulating through all the ways for the perfect ventilation of the pits, and safety of the men, up to the time of the explosion. The four men on the north rolleyway were working with open oil lamps at the time of the explosion. There were no other naked lights but Gleghorn and Bond's, who were about 900 yards north, and 300 yards east from the downcast shaft. Gleghorn and Bond were saved. The men working upon the north wagonway could not work with any other lamp, the current of air was so strong. The air was coming direct from the shaft to them.

John Curry—I am a furnaceman. On Thursday, the 20th December last, I had charge of the east furnace in the East Minor Pit. At four o'clock in the afternoon I took charge of it, and remained there until the explosion. When I took charge I did not see anything particular or unusual. There was no appearance of gas anywhere about, nor had I observed anything before the explosion took place to lead me to suspect

any danger. Between eight and nine o'clock the explosion took place. I was just going in to fire at the time, and the strong wind, from the force of the explosion, met me. The furnace was in a good state before that, the fire was good and a strong air coming to it. By firing I mean supplying the fire with coals. I had supplied the fire with coals about five minutes previously. After I felt the wind of the explosion, I found the air come back from the furnace instead of going to it. As soon as I felt the wind I made my way through the first door coming out to the downcast shaft. The force of the air was very great before I got through the door, but after I had got through I did not feel it so much. I got out by the Eppleton Pit. I thought the air was good when I went in, and it continued so up to the time of the explosion. I can form no opinion where the explosion took place. I have not been down the pit since, but the force of the explosion came from the upcast shaft. The furnace fire had been out a week before that, when the water was coming down the shaft. I think it was out about three days, but I cannot exactly tell. The other two furnaces were at work when mine was out. I never heard of any gas in the pit. My furnace was lighted two or three days before the explosion took place, but am not certain. The furnace was going as usual after it was set away again. I form my opinion by the force of the draught going towards the furnace. I cannot say that the gas did not fire at my furnace. I did not see any of the flame of the explosion. There is only one current of air comes to my furnace. If it had gone down my return I must have seen the flame of the explosion. I saw no fire, and was not burnt. I would be five or six yards from the furnace when I felt the wind. The air that came from the explosion was not hot when it came to me.

Isaac Lowthian Bell, of Washington, said—I am an ironmaster and chemical manufacturer. I have not been accustomed to investigate matters of this sort connected with collieries, but from having between 20,000 and 30,000 cubic feet of gases per minute to deal with as an ironmaster, it has led me to study gases particularly. I went down the downcast shaft of the East and West Minor Pits this morning, and spent two hours in examining the flue in which the explosion is alleged to have taken place. In the first instance, I found a damper within six feet of the boiler, broken in two, the lower portion resting in its place, and the upper portion, as one might have expected from the counterbalance weight, drawn upwards; a jacket close in to the other end of the boiler, burnt; some wood-work nearly opposite to the boiler, charred; and

wood-work and stone blown in the direction from the boiler. I found doors blown down, all indicating the direction of the explosion to have been from the boiler. I found thirty feet of the flue between the damper and the upcast shaft blown out. I found the whole of the lateral flues (of the pipe drift) opposite the pipe drift blown outward. From that point for about thirty feet the flues and travelling way were whole, arising, no doubt, from the greater strength of the flue, or less intensity of the explosion; then about fifteen feet of the top of the flue blown outwards, and about ten feet of the covering of the travelling ways also displaced. At the crossing over the way leading to the downcast shafts, the flue being unsupported either on one side or another, was burst. The walls on the north side were blown to the north, and the south walls to the south, and, generally, the indications of the explosion at the crossing were as if the explosion had proceeded from the crossing as a common centre. From there I continued along the flue towards the furnace, going to the upcast shaft. The soot had evidently been displaced from one end to the other. At the bend next to the furnace there was a little displacement of brick-work. At the end of the north furnace a bridge of brick-work was blown over in the direction which an explosion in this flue would render probable. Immediately opposite, there is a furnace drift proceeding from another furnace, in which, where it crosses a road, I found the arch displaced. After seeing all this, the question arose, could a flue of these dimensions contain sufficient gas to cause such an explosion? and, secondly, if it could, where did the gas come from? I conclude the gas could not come from the workings, because the boiler furnace always has been, and is now, exclusively fed by air proceeding direct from the downcast shaft without going into the coal workings, assuming that the ventilation was maintained in a proper way. I find, by computation, that this flue contains 7000 cubic feet, and to fill that flue with light carburetted hydrogen, leaving a sufficient content for the necessary atmospheric air to thoroughly explode the light carburetted hydrogen so contained in the flue, 150 lbs. of fresh coal would furnish the whole gas necessary. The length of time to do that would depend upon the heat applied to the coal. I find, to fill the same flue with another explosive gas, carbonic oxide, leaving space for air, 40 lbs. of coke would be sufficient. Supposing the flue to be filled with either of these gases, together with the necessary atmospheric air required for their explosion, at a time when there was no fire to cause the explosion, that is, no flame in the furnace to cause the ignition of these gases, which

might readily occur from damping the coals, then the combustion of the coal at the boiler end or the furnace at the far end, either one or both, could easily supply the flame for setting on fire this inflammable gas. Supposing this to have occurred, is the damage which ensued a probable event? I may state that, in my own experience, I had a wrought iron pipe, three feet in diameter and about 100 yards long, filled with an explosive compound, in which the combustible gas was carbonic oxide—the less explosive gas of the two. It has about half the explosive power of light carburetted hydrogen. That pipe fired at one end at a lamp, blowing the man holding the lamp many yards into the air, breaking every bone in his body, destroying the whole length of the pipe, and splitting the blowing apparatus of metal, which was three-quarters of an inch thick at the far end. My opinion is based upon these facts, and upon philosophical calculation of the power of such a quantity of gas, or much less, and I conceive that the results I have this day seen are easily accounted for. As soon as the contents of the flue took fire, supposing it to be filled with a mixture of light carburetted hydrogen gas and atmospheric air, the 7000 feet contained in it would instantly become about 56,000 feet. Of course, that increased volume would rush in the direction of the least obstruction; and, as I understand, the men, or most of them, were found in the way in a direct line from where the explosion took place, the contents of this flue would be instantly converted into after-damp by the explosion, and being taken up by the natural ventilation of the colliery, would be carried into the workings, and thus cause the death of every man over whom it passed in its way. I think it highly probable that the explosion might set fire to the north stables, which are at a distance of three hundred and fifty yards, not because flame would travel that far, but because particles of inflammable matter, set fire to by the explosion, would be driven in the direction of the stables, and besides the temperature of these exploded gases being about 1500 degrees of Fahrenheit or more, or a very bright red heat, would of itself, if coming near hay or straw, immediately set fire to it; and in this way, as far as I have seen, I consider everything can be fully accounted for. It would take seventy-five quarter casks (of 25lbs. each) of gunpowder to produce the force such as the quantity of gas exploded as described is capable of exerting. In these calculations I took a ton of coals to produce 10,000 cubic feet of light carburetted hydrogen, and about 650 feet from 150lbs. of coal, and add about nine and a half times that of atmospheric air, which makes 6835 of explosive mixture. A quantity of soot deposited in the flue, assuming that no steam was present, could not

have added to the explosion. Assuming that steam was present, I consider that the explosion might possibly have been increased in intensity. The flue is ascending, and I think it improbable that the gas would have lodged in it, but still it is possible. I think it highly probable the gas might lodge from the boiler fire to and inclusive of the crossing. All calculations based upon the difference of the specific gravity of gases are liable to disturbance by differences of temperature, by which means a cubic foot of heavy gas may be rendered lighter than a cubic foot of lighter gas, according to the temperature. If the gas was only contained in that portion of the flue (I mean between the crossing and the boiler) it would reduce the quantity of the gas to about 3000 cubic feet. The explosion of that quantity would be quite sufficient to account for what I found. I think the only explosion took place in the flue. I think that gas over-saturated, or under-saturated, above or under the proportion of nine and a half of air to one of gas might have the effect. After the crossing was blown down, a larger amount of air would be admitted to mix with the hydrogen gas, but I cannot positively say whether it would increase the explosion or not. There is no reason which I can give at present to account for the gas accumulating and exploding on this occasion when it has not done so for so many years. It is one of those occurrences affected, to some extent, by the doctrine of chances; that is, you require inflammable gas, atmospheric air, and fire, contemporaneously; any one of these wanting and no explosion ensues. I do not think the state of the weather affected it at all. If the damper had been hermetically closed, inflammable gas would not have been found there. Its being partly open would add to the generation of gas, and also supply air. It is my opinion the explosion cannot have taken place in any other manner than I have explained, from the direction in which the bricks have been thrown and are lying, and from the other appearances in and about the flue. If a large quantity of fire-damp had come down the downcast shaft, going over, not through, the fire, and filling the flue, a similar explosion might take place, if by any means fired. If no large quantity of gas came down the downcast, nor from the inbye workings, to fill the flue, I do not consider it possible to have taken place from any other gaseous elements from any other place than the boiler fire. If 160,000 cubic feet of air were coming down the downcast shaft per minute, it would have to meet with 16,000 of fire-damp per minute to make it explosive to the extent that I have supposed it may have occurred in the flue; but having to pass two other boiler fires would cause the explosion to be totally different, and the indications also, to what I found them.

William Gardiner, miner—I was at work in the East Minor Pit on the day of the explosion, down the east bank, about 770 yards from the shaft. Whilst we were working, near nine o'clock, a mighty rushing of wind came upon us—it blew our lights out. I went up the bank first and met the stythe, and then came back and went by the return to the furnace, and then towards the shaft, but we were obliged to turn back again, and then we went back to the furnace and staid till Mr. Daglish and others came to us; we then went down the return and through to the Eppleton Pit and got out. We found the after-damp first on going up the east bank—it was going from the shaft—it was very strong. Shortly after the explosion, the direction of the air was reversed, and soon afterwards it was again reversed. I have seen the damage done by the explosion. I am not able to form an opinion where the explosion took place, or the cause of it. There was no accumulation of gas in the workings that I know of. The ventilation where we were working was in full operation. I cannot form any opinion where the gas came from which caused the explosion. The air where we were working was good up to the time of the explosion.

Ralph Hope, miner—I was in the East Minor Pit at the time of the explosion, at the east bank. After it had taken place, I and William Gardiner, Robert Gardiner, Joseph Scott, William Anderson, and Thomas Smith were together. We went first up the east way towards the shaft. We met the after-damp a good bit down the bank—it was very strong. From the effects of the after-damp, I cannot recollect which direction we took. I was insensible, and was carried out of the pit. The after-damp was going inbye when we met it, from the shaft. Up to the time of the explosion the air was good where we were working. There was no gas there at the time. I have no idea how the explosion took place. I considered the pit perfectly safe before it.

Robert Simpson, shifter—On the day of the explosion, I was working down the east bank of the East Minor Pit. After the explosion, I went up the east bank. We met the after-damp coming from the shaft, a good bit down the bank, it was very strong. We came back and went into the return drift, and proceeded to the East Minor shaft. We got out by the Eppleton Pit. Up to the time of the explosion, the air where we were working had been very good. There was no gas. I cannot form any opinion as to where the explosion took place, nor the cause of it. I had previously considered the pit perfectly safe.

John Bond, wagonway man—On the day of the explosion, I was

working in the north cross-cut, down the east bank of the East Minor Pit. Before the explosion, the air was very good. There was no gas. I considered the pit perfectly safe. We were working with two oil lamps. One of them was blown out by the force of the explosion. We proceeded to the east bank, and met with the Gardiners and Smith. We first met the after-damp at the bottom of the bank, where we came out from the north cross-cut end, about 600 or 800 yards from the shaft. It was not strong there. It was coming in the direction from the shaft. It got stronger as we proceeded towards the shaft up the east bank. We were obliged to return. We proceeded up the return to the shaft. We remained there eight or nine hours, and then got out by the Eppleton Pit. It was the main wagonway where I was working in the first of the air. If I had considered there was any danger, I would not have gone down that night, but I thought I was as safe as I am standing here. We were working about 800 yards from the shaft. The force of the explosion threw me and my mate down. The place where we were was six feet high and eight feet broad. There was only one blast of wind.

George Gleghorn, pitman—I was working with John Bond in the north cross-cut of the East Minor Pit, at the time of the explosion. We had two naked oil lamps. The force of the explosion threw us both down, and blew out one of our lamps. Before the explosion the air was very good. There was no gas where we were. I considered the pit perfectly safe. We met the after-damp nearly at the top of the east bank, it was very strong, and coming in the direction from the shaft. I am not able to give an opinion as to where the explosion took place, or the cause of it.

Robert Gardiner, hewer—On the day of the explosion, I was at work with my brother on the east bank of the East Minor Pit. Before the explosion the air was very good—there was no gas. We met the after-damp a little up the bank. It was very strong when we got about three parts up the bank. It was coming from the shaft. We got up the Eppleton Pit. I cannot form the least opinion as to where the explosion took place, or the cause of it.

William Anderson—I am a stone workman, and was at work in the East Minor Pit, on the 20th of December last, at the north cross-cut, down the east bank. When the explosion took place the air was very good. We found little effect from it, merely a ringing in our ears. We would be about a mile and a quarter from the shaft. I have heard of no gas in any of the goaves that could have caused it. My opinion is if it

had come from the goaves to the furnace the furnace would have been blown to pieces, and it is undamaged.

James Reed—I am master wasteman of the East and West Minor Pits. I was down the East Minor Pit on the morning of the day of the explosion. I went down at half-past two o'clock in the morning, to set my men to work. After I set the men to work, I went in the wagonway of the East Minor to the bottom of the new south incline, into the return. I met George Lowden at that point, to arrange about some stores he wanted, and I then went into the waste, and examined further in than is shown upon the plan. The ventilation was capital—in a real good state. There was no accumulation of gas; I do not believe an inch. I examined every part of the returns of that pit up to the furnace, and found nothing but well, all ways. I left the pit about a quarter-past eight o'clock in the morning. I examined all the places that morning, and they were all clean. I have examined many a time the place where the explosion is supposed to have occurred. I am of opinion it took place in the flues. I think it had been gas in the flues, but I cannot tell how or why it had come there. It could not, I think, possibly have come down the downcast shaft, and so got to the flues. If the ventilation was perfect, gas accumulated in the workings could not get to the flues, nor even if it was imperfect. I know no other place where it could come from, except the coals put on the engine fire for damping. There were some repairs done in the upcast shaft. They commenced on the Sunday before the explosion, and concluded on the Tuesday previous. The wedging of the tubbing had given way, and some water was going down the pit, which interfered with the ventilation, but not to any considerable extent. The ventilation was perfect again on the Wednesday morning. These repairs could not in any way have assisted in causing the explosion. The principal returns were examined on the Wednesday morning, but I found not the slightest gas. Whilst the repairs were going on in the shaft, the High Main furnace was going in full operation. The two west furnaces in the Hutton Seam were also going, but not in full operation. The east furnace was out, or nearly so, and the three boiler fires were on to a certain extent. The dampers were down, but the fires were not damped. [Mr. Reed then explained the mode of repairing the tubbing.] During the stoppage we had as much ventilation as before the furnaces were put out. Before recommencing work the High Main was examined, and there was no gas in any of the edges of the goaves. I examined the intake and the outtake of the Low Main myself, but not inbye, and I found her clean. I have known the Low Main twenty-

three or twenty-four years, and never saw an inch of gas in her. It gives off less gas than the other seams. I do not think that gas, during these repairs, can have accumulated to any extent in any part of these pits. If it had been, I do not see the possibility of its getting to the flues with the benefit of the portion of air going to Eppleton from the Minor Pit, which supplied the east, north, and west districts of the East Minor Pit, which was a benefit to the West Minor Pit. What the Eppleton Pit upcast took was a benefit to the West Minor Pit. At the time of the explosion I think we would have 157,668 cubic feet per minute going down. That was measured a fortnight before the explosion. It does not surprise me, with that quantity of air, that there has been so much after-damp from the explosion. I know, of my own knowledge, that men have been suffocated, at considerable distances, in all directions from the shaft. I have travelled some distance underneath after-damp, but not a considerable distance. The furnaces, after the explosion, did not assist to make after-damp. The burning of the hay in the stables I think would. It made a serious quantity of smoke. I do not think any man could have lived where it was very strong for any length of time. I believe there has been no other gas, except what was in the flue, to cause this explosion. There was no possibility of gas getting from the Low Main to the flues, because the flues were shut off altogether, and it could only get through the damper, and would have to pass over the fire, and, although damped, would have exploded, and gone back to the Low Main. Gas generated in the Low Main would make for the upcast. If gas came down the downcast shaft, and so over the fire, it was impossible for it to get into the flues. If it did, it would pass No. 1 and No. 2 boilers before it came to the flues. No. 3 boiler has flues: the others have none. I do not think it possible for any gas to come down the downcast, from the quantity of air we had. There was no goaf to foul from in the east, and the returns were examined in the west, and no gas found. I think it is possible, with so large a quantity of air, when the ventilation is broken, to have as much after-damp as in this explosion.

George Lowden recalled—After the stoppage, on the Sunday previous to the explosion, I examined the whole of the driftways, but found no gas. I examined the waste, and the workings which belong to us, but not the stables. They are the only part I did not examine, and they are in the first intake of the air. It would not be possible for gas to accumulate there.

George Davison, engineman—I had charge of the engine in the east

side of the East Minor Pit. I took charge of it at four o'clock in the morning, and continued in charge up to about ten minutes to five o'clock in the afternoon. Up to that time my engine had gone all right, and the ventilation also. The fire was damped when I left. I did not examine the steam valves, but I examined the steam gauge immediately before I left; it indicated 18lbs. on the square inch. It might have been worked at 33lbs. on the square inch—that is the ordinary pressure. The damper was out a little to take away the smoke. I think it would not be more than an inch and a half open. I did not see the damper, but ascertained by the weight and chain attached to it, which I did see. The fire would be damped by the fireman, William Clennell. After the fire is damped I think it will give off less smoke than before. I cannot say that damping would cause more gas. After a time it would give off more smoke. There was a little scale of fresh air from the top of the damper. I did not hold my lamp to it that day before I left the pit. A week after the explosion I saw my boiler and engine. The boiler was standing in the same place where I had left it. I examined it that day by looking round it. It had not been displaced. I have not examined it inside. I had examined the boiler before I left on the day of the explosion, but there was no leakage. The smoke would go through the scale left under the damper and so into the flues. The draught was only sufficient to take away the smoke "cannily" into the flues. The fire was damped in the usual way. The opening of the damper is regulated by guess, according to one's own idea of the space required. The damper could not have been nearly down without my knowing—the smoke would come out in a contrary direction. If the damper was down to the bottom there might be a bit scale at the sides, but it would not take away the smoke. The grooves in which the damper worked were formed of fire-bricks, and not metal, and there was a small leakage into the flue. The brick grooves would not fit the damper as perfectly as metal—it would admit more space for gas to get into the flues. I cannot say anything about gases. It is the first time I have heard of or seen fire behind my engine. I have been an engineman twenty-four years, and had charge of this engine two years. I never knew a case of gas firing behind the damper, nor in front of it. I have seen a little on the fire—a bit "flisk." When the damper was in and was lifted it gave a bit explode. That was at bank. My damper was not broken when I left it before the explosion, but is so now. I think it might be broken by an explosion of gas inside the flues. If the damper was put too close, the

draught would have come back. There was always sufficient draught to prevent back draught through the fire doors. The fire doors were open when I left, and every thing else was left as usual, and, as I considered, perfectly safe. No alteration has taken place in the boiler or the flues for some time. About ten months ago the boiler was repaired and the side flues built up again in the same way as before. During Monday and Tuesday previous to the explosion I was at my boiler. I was driving the engine on these days pumping water. I was pumping water by the force pump out of the Hutton Seam to the main coal. My engine worked night and day these two days. Once before, when cleaning the drift out, about three weeks before the explosion, she went three nights and days, and nothing unusual occurred. I have examined my flues since the explosion, and see they are blown up in two places. I think it was gas in the flues that caused the explosion. I cannot say where the gas came from. We had plenty of air coming to the fire on the Monday and Tuesday, and I saw no difference on the Wednesday, and on the Thursday it was coming just the same. The fire burned sharper in cold weather. We do not put the damper further down than in hot weather. Two or three hours after being damped a flame might play about the fire. The fire is sometimes green when damped. At the week's end we burn her down to damp. I think there would be more cinder than green coal on when she was damped. There was a little flame playing over the top after she was damped that night, at the backside. There is sufficient flame at the backside to explode fire-damp if it came back from the flue. If the same gas as is made in the gas works was in the flues, and had come back upon the fire, it would have lighted. There was nothing to prevent the damper falling down. I never cleaned the framework of my damper. Dirt might accumulate, and dust also. The distance from the firebars to the damper is about sixteen or eighteen feet. There is a flue with an end door to it at the entrance to the boiler, on the right hand side. The door was kept open always. The air might get in there. It had no connection with the centre or smoke flue. There was no opening into the centre flue that I know of. If gas was coming in at the door and over the fire, if it came in contact with the flame it would ignite. I am quite sure my damper was not left half-way up that night. As soon as the fireman puts the fire in he damps it, and I see if it is right. One night it might be half an inch lower than another without my knowing it. I think about a tub of coals, which is eight cwts., is required to damp the fire. On

returning in the morning, eleven hours after, I cannot say more than a quarter of it would be burnt. The fire burns more to the back, and in the morning there is both cinder and green coal. When we commence to damp, there may be a tubful of fire on the grate bars. The flame at the back of the fire was not peculiar to that night. There is generally a little flame there.

William Clennell, fireman—I was employed as a fireman at Davison's engine, and had been three months previous to the explosion. I went down about half-past four o'clock in the morning, and left at ten minutes to five o'clock in the afternoon. All had gone right with the boiler fire, just as usual, up to the time of my leaving. I damped the fire before I left. It had been burnt down as usual every night, and about half of it would be cinders, and half green coal. There would be better than half a tub—not quite a tub. I put on a tub and a half, or two tubs at the outside, to damp the fire. I saw the damper put down by Davison. That was when I had got the fire about half damped. The damper was usually left an inch and a half open, just to take away the smoke. The weight attached to it hangs almost against the wall, and I can tell by guessing what is the space left open. I left the fire doors open as usual when I left. Gas is a thing I know nothing about. I have never seen the engine or the boiler since the explosion. I have seen the damage done by the explosion, but I cannot form any opinion where it took place, or what caused it. This is the first underground boiler that I have tended, and that only for three months. This is the first time I have known an explosion of this sort. When I left, I had no apprehension of danger. When we come in a morning, sometimes the steam was blowing off, and sometimes not. Sometimes the fire was well burnt up at the backside when blowing off, and sometimes black.

Thomas Richardson, of Newcastle-upon-Tyne, reader in chemistry in the Durham University, chemical manufacturer, analytical chemist, and LL.D., said—I have been down the pit, and have examined it, and am able to state where the explosion took place. I found considerable damage to the flues of Davison's engine. I heard the evidence given by Mr. Bell of the injury done to the flue, and I believe it to be true. I do not think I noticed any further injury than he has described. I am of opinion the explosion has taken place between the boiler of the engine and the crossing of the north rolleyway. From what I have heard given in evidence, and my own examination, I believe the destructive effects which I noticed in connection with the damage done, arose from an

explosion of gas in the flue between the boiler and the crossing. There was about 3000 cubic feet of flue between the boiler and the crossing, which would contain that amount of gaseous matter. The gas might be an explosive mixture, which might be a mixture of various gases. It might consist of carbonic oxide, light carburetted hydrogen, or olefiant gas, or a mixture of the three or any two of them. These gases might come from the destructive distillation of the fuel used in firing the boiler, which would proceed from the fire grates under the boiler, and pass underneath the damper into the flue, if the damper was open only an inch and a half. The space between the bottom of the damper and the sole—the heat of the flue—the draught of the upcast shaft—the temperature of the air admitted to the grates—the quantity and condition of the fuel used at and previous to the damping—are all points which would affect the filling of the flue with explosive gas; and if the combination was favourable, the flue would be so filled. The result proves that the combination must have been favourable to it. The evidence I have heard, and what I have seen, leads me to think so. I think there is no other mode for accounting for the explosion but the one I have given. Three or four hundred cubic feet of a mixture of these gases in the flues between the boiler and the crossing would cause, on explosion, the damage I found. As far as I understand the working of this pit, I consider it impossible that the explosion could have been from an accumulation of gas in the workings carried into the flues. If gunpowder had been in the flue, it might have caused some of the damage I have seen. It would require seventy-five quarter-barrels of gunpowder to cause the same effect as the gas contained in the flue. The first effect of the explosion would be to prevent the usual ventilation of the pit, and the after-damp would be carried by the current of air. A small quantity of after-damp would vitiate a large quantity of air; in fact, ten times its own quantity. It would be impossible to ascertain the amount of carbonic acid gas after the explosion, without knowing the composition of the explosive mixture in the flue at the time, and also the soot in it; and the combustion of the soot would increase the production of carbonic acid gas, and there would be in the flues sufficient heat generated by the explosion of this mixture to ignite the soot. I find, in a work entitled "Bunsen's Gasometry," by a German chemist of the name of Bunsen, published in 1857 by Walton and Maberly, that the temperature of the gases I have alluded to, when exploded, is very much higher than I had previously calculated upon,

and which strengthens the opinion Mr. Bell and myself have already enunciated. Flame from a gunpowder explosion would not have extended so far as to set fire to hay in the north stables, a distance of 350 yards from where, I think, the explosion took place. The soot, if it had been ignited, would be carried to the stables in the same way, or the hot air either from a gunpowder explosion or the gaseous mixtures I have noticed. The stables have been set on fire either by the heated air of the explosion, or by incandescent particles taken by the air. The evidence of the burning of the men is very slight, and is nothing more than can be accounted for by the heated state of the gas or air. I know the concussion after the explosion at Newcastle was so great as to put out the lights in a manufactory at Jarrow Slake, a distance of eight miles, and that is why I consider that, the men being knocked down by this concussion, a very small quantity of after-damp would then kill them, when it would not a man in robust health, at the distances I have heard they were found. I cannot find any other cause for the explosion than the one I have pointed out. It is a direct and feasible one. Olefiant gas is a highly explosive gas—much more so than any of the others. I never met with it in any analysis of fire-damp from mines that I have made; but it is said to exist in the mines of the Rhine. It may be produced from coal by distillation. It might be so distilled from coal consumed in a fire damped as I have heard the fire at Davison's engine was. It is a constant constituent of our house gas. Ten per cent. of carbonic acid, mixed with air, would destroy life, and also put out a candle, but I cannot say what is the least per centage to put out a candle. The margin between the destruction of life and a candle being put out is very little. I have passed up the north rolleyway, and seen the effects of the explosion, and I believe, when the products of the combustion in this flue found vent into that north rolleyway by the destruction of the crossing, they would fill that rolleyway to such an extent as to pass on and destroy these men, having previously interrupted the usual ventilation. Carbonic acid and nitrogen mixed is after-damp. There is 20 per cent. of oxygen in air. I cannot say what deficiency of oxygen in air would kill a man. I cannot make any computation. I never heard of a man out of the flame being burnt by heated air in an underground explosion, but I can quite believe in its possibility. It depends upon circumstances. I think the explosion would have gone straight away if it had not been for the obstruction of the crossing, which was on a rise, and which diverted it north and south. It is possible the gas

in the flue was in greater proportion than 1 in 10 of air, and that, on the explosion breaking the crossing down, the unconsumed gas got its proportion of air from the intake, and so increased the force of the explosion; but I do not think it probable. The concussion of air might kill these men in the south and north rolleyways, unmarked by violence, without any after-damp. If any difficulty arose to account for the ignition at the damper, it might arise by a tailing back of the gas at the roof of the arch from the furnace to the seat of the explosion from the ventilating furnace.

John Daglish, of Hetton Colliery, viewer to the Hetton Coal Company, said—The Hetton Colliery consists of three distinct collieries, Elemore, Eppleton, and Hetton. There are two distinct shafts at each colliery, one used as a downcast the other as an upcast. The Eppleton is connected with the Hetton, but the Elemore is not. The area of the downcast shaft of the East and West Minor Pits, after deducting for slides, brattices, &c., is 98 feet clear, and that of the upcast 132 square feet. The intakes and outtakes are considerably larger, I might say four times that size. That will allow 230,000 cubic feet of air to circulate. We have measured that quantity in the upcast, and, at the same time, there was 180,000 cubic feet in the downcast. That quantity of air was circulating in the East and West Minor Pits immediately before the explosion. The increased temperature in the upcast shaft apparently increased the quantity of air. The last measurements of air were taken a fortnight previously. The day of the explosion was the regular day for retaking them. That quantity was sufficient for the perfect ventilation of the pits. With that circulation, gas could not accumulate in the workings of the pits. There was no alteration made in the length or direction of any of the currents, and the water gauge was standing at the same point at the time of the explosion as at the time of the measurement a fortnight previously. The water gauge denotes the difference in pressure existing between the downcast and upcast shafts, and is, therefore, a measurement of the ventilating power. The water gauge is taken every hour, and a return made to the master wasteman every night, who enters it on a diagram, and forwards it to me for inspection every night, and from these reports I can tell any neglect on the part of the furnacemen. The greatest variation of pressure during the day of the explosion did not exceed two-tenths, which is very regular. At five o'clock it was 1·5; that is two-tenths beyond what I require—1·3 is the standard of that pit. Up to that hour the ventilation had been perfect. On the

Tuesday night before the explosion I examined the water gauge myself. We have a barometer in use in the pits, one at each colliery, and also at bank in connection therewith. They are registered daily, both on the surface and in the pits, as well as the thermometers. If there was a sudden fall in the barometer, reducing the atmospheric pressure, if there was any gas in the goaves it might come out. The object of these regulations is to insure watchfulness on the part of those in charge as much as anything else. The barometer in the pit indicated, on the morning of the explosion, 30·1, being a rise of three-tenths above the day previous. It reads higher than the surface barometer, which reads half an inch below that of the pit. On the day of the accident, I had reports from all the men in charge. I receive such reports, twenty-eight in number, every night, besides the water gauge diagrams from each pit. I received the reports the night previous, but for the day of the explosion I received them immediately afterwards. They had been made immediately before the explosion, and the boy was on his way to me at the time of the explosion. The ventilation of the mine is produced by a difference of the weight of air in the downcast and upcast shafts. The buoyancy of the upcast is caused by highly heating the air by means of four furnaces in the Minor Pits, and three engine fires—the air rushes down the downcast in order to ascend the upcast. The water gauge may be explained thus:—A communication pipe is put between the two shafts, and attached to it is a tube of glass, bent in the form of a U, which is partly filled with water, and the air of the downcast pressing on one side of the U raises the water in the opposite leg, and thus indicates the amount of the ventilating pressure. In this instance, the difference in the level of the water was an inch and a half, which is equivalent to about 9lbs. pressure per square foot, equal to about 11,000lbs pressure over the whole area of the upcast shaft. There were 37,000 cubic feet, by anemometer measure, going into the south way, which, making allowance for the friction of the instrument, would be 40,000 as measured by gunpowder smoke. That was immediately before the explosion. In the north way there were, by actual measurement by gunpowder smoke 46,000, by anemometer 44,000. With air thus circulating, it is impossible for gas to accumulate in the workings. The extreme distance the air has to travel, from the downcast shaft to the extreme portion of the south way, is 1400 yards, and of the north way, 2600 yards. The north way is the furthest the air has to travel. The reports for the day on which the explosion took place were all good. I

produce the report, marked A, of James Dakers, the person in charge of the north way, up to five o'clock of the day of explosion, in which he says "pit all right." I had, also, a report from the witness Young, which was to the same effect. The master wasteman and his son send in a joint report. James Reed each day gives a report of the districts through which he has travelled, and also as to the ventilation of the pit, which report I produce, marked B, in which he states "all going on as usual." None of the reports, received that day, indicated the presence of gas in any portion of the pits. The quantity of air, we consider, we had in the pit at the time of the explosion was not only sufficient for the ordinary requirements of the mine, but intended to be sufficient under unusual circumstances, such as occurred on the Sunday previous to the explosion; and as proof, I would state that after the explosion, owing to the destruction of the stoppings and crossings at the end of the south drift, and the entire interruption to the ventilation of that part, a large quantity of gas accumulated, the whole of which has been removed by the present limited ventilation, without any appearance of it in the vicinity of the furnaces, although, since the explosion, all the three furnaces in the lower seam, and the three engine fires are out. The size of the furnaces are as follows:—the large east furnace, ten feet; the two west, eight feet each; and the main coal, between six and seven feet. These furnaces are for the ventilation of the pit. There is now one-third of the air circulating (owing to the furnaces not being in operation) that there was previously to the explosion; but the south way is not getting its full supply, on account of the contractions in it from the falls. Therefore, one-fourth of the ventilation, in operation previously to the explosion, was sufficient to carry off all gas accumulated during the fortnight since the explosion; not only all that was made, but also what had accumulated. The diminution of the air in the downcast was two-thirds, in consequence of the furnaces being out, and from no other cause. The downcast shaft is now divided into two pits by a brattice. It was at one time both an upcast and downcast shaft; but the Blossom Pit was some years since sunk down to the Hutton seam, and made an upcast, and since then both sides of the brattice have been used as an intercommon downcast shaft. That was done for the better ventilation of the colliery. I first heard of the explosion between eight and nine o'clock on Thursday night, the 20th of December, and I immediately went over to the pits and tried both engines of the East and West Minor Pits to get down, but found there was some obstruction which prevented the cages being

drawn up by either of them. The upcast in the Blossom Pit is fitted up with wire rope guides to the main coal, and is used for drawing the coals from that seam; but as the guides do not go down to the Hutton seam, there is no access to it by this pit. There was then no means of getting down into the pit, so I at once rode over to Eppleton. On my road, I called on the underviewer of that colliery, and by the time we were ready to go down, Thomas Reed and Robert Young also arrived, and with two other men we descended the pit. [The witness then described the exertions used to get to the Minor Pits from the Eppleton Pit, and the manner in which the Eppleton air current was diverted to enable the exploring parties to reach the Minor Pit, and recover the survivors. He then resumed]:—In company with Mr. Heckels, Mr. John Taylor, and other gentlemen, I proceeded to examine the boilers, where we had the idea of the explosion having occurred. We noticed the direction of the blast as we proceeded, and on arriving at the end of No. 3 boiler, at the damper end, we found the entire flue blown away from the damper to the pipe drift—the top of the flue had been blown from the inside. Opposite the pipe drift, the sides of the flue, the whole flue, the travelling flues, and the brick work were blown away at that point. Following up the flue to the north wagonway, we found the arched crossing which carried the flue over it completely gone—the sides left standing, and the sole gone—which shows that the force came from above, and that part of the crossing next to the boiler was completely blown to pieces. On the opposite side, part of the crossing was left, showing that the blast had come from the direction of the boiler, and had found full vent at this crossing. I have also examined the continuation of the flue towards the furnaces. Here it is solid, and the apparent damage is not so great, but still following the direction of the blast from the boiler, but with diminished force. At the first turn, a few bricks were blown out, from the direction of the boiler; also, at the next turn, near the furnaces, and a small wall between the flue and the furnaces was overturned, still in the same direction. We have no further indication of the force of the blast in this direction, excepting from the witness Curry, at the east furnace. I have examined the pit in all the parts we have been able to get into, and in every direction I find evidences that the blast has proceeded from the neighbourhood of the damper of No. 3 boiler, which satisfies me that that was the seat of the explosion. Further, I also find that the blast has acted with diminished force in all directions from the damper, in some cases entirely ceasing where the

distance is far enough. In the north wagonway we have no evidence of force beyond the crossing joining the travelling way to the Eppleton Pit, a distance of 1600 yards, although it had killed and mutilated four men at an intermediate point, about 600 or 700 yards from the shaft. Beyond the crossing no damage whatever was done. In the south part, beyond the crossing in the old bank, little or no damage has been done. That is 700 yards from the shaft, and about 100 yards beyond the foot of the new bank, where Ferguson and another man were found. In the other parts of this way the stone is so extremely bad that it is difficult to say where the blast has ceased its violence, such a large quantity of stone has fallen since the explosion. This we know by the whiteness of the roof. On the straight road the damage is greater than on the other ways, on account of the divergence of the blast, and the space allowed for its expansion. In the direction from the shaft, at right angles to the north and south ways, the damage done is comparatively slight. The size of the drift near the shaft being considerable, caused it not to be so great, but there was damage done sufficient to show the direction of the blast; and there is also the evidence of the men who felt the blast down the east bank. From all this, I come to the conclusion that the flue was the place where the explosion took place. I know, of my own knowledge, sufficient of chemistry to enable me to account for the violence of the explosion; and my own views and opinions are confirmed by the evidence of Mr. Bell and Dr. Richardson, which I have heard. I know that the coal put upon the boiler fire to damp it during that night, must have given off the whole of the gaseous matter it contained, which would, from the evidence of the fireman as to the quantity of coal he used, amount to 7000 cubic feet of inflammable gas, which requires ten times that amount of atmospheric air for its perfect combustion; and as the cubical contents of the flue are about 7000 feet, the gas given off from the coal mentioned by the fireman was sufficient to fill these flues ten times with a perfectly explosive mixture. That is how I account for the gas being there. It might have fired either at the ventilating furnace or the engine fire. I believe that there is very much greater power developed than is due merely to the quiet expansion of the gas, owing to the temperature of ignition. If we take gunpowder, over which we have more control, an ordinary charge for a rifle is equivalent to fifteen cubic inches; and taking its expansion due to the conversion both of the solid into the gaseous, and also the further expansion due to the temperature of ignition, and both these two at 2000 volumes, we have the ultimate expansion of

a charge of gunpowder to be equivalent to 300 cubic inches. Take the bore of a rifle to be three-quarters of an inch, the area will be five inches; and if you take the length of the barrel to be thirty-six inches, its cubical contents will be eighteen inches, and as the ultimate expansion of the original charge was only 300 cubic inches, this is only equivalent to sixteen times the length of the gun barrel; whereas the ball is sent a mile and a half. And if so small a charge can project a ball to such a distance, I can readily believe that so large a quantity of gas collected in the flues when exploded is capable of doing all the damage which I have seen in the pit, especially considering that the damage is mostly confined to two single drifts. The gas could not have come from the workings of the pits, and I do not think it could have come from any other place than the boiler fire. The plans produced are correct ones of the workings, flues, &c., of the Minor Pits. [In explanation of the east furnace being put out on the Sunday night before the explosion, the witness described the nature of the repairs made in the Blossom Pit previous to the explosion in the Minor Pits. That the east furnace, in the Minor Pit, was put out, and the two West Minor furnaces were damped up; but the main coal furnace and one boiler fire were kept away in full operation. During this time, the regulators between the Hetton and Eppleton Collieries were opened wider than usual, which allowed a larger quantity of air to pass from the Eppleton Pit into the Minor Pits to prevent any accumulation of inflammable air. The witness resumed]:— The alteration in the air at this time could have nothing to do with the explosion, and could not have drawn any gas from any splits there might be in the pit. The whole of the south way was not interfered with. No part of the workings were laid dormant whilst this work was going on. There is a distance of two or three yards between the fire and the end of the flue of the ventilating furnace. The air passes all the edges of the goaves in the East and West Minor Pits, and so sweeps away any gas there may be. Some of it may be black damp, and some fire-damp, but it is regularly swept away as it is given off. When carried away by the air, it would pass over the furnace, and not into the flue. Gas coming off the goaves could not get into the flues. If the gas was so given off as to contaminate the whole of the return air-currents, being all mixed before they arrived at the furnace, and if they had been inflammable and set fire to by passing over the furnace, the explosion would pass back along the returns to where it came from, and its effects would have been there seen, and not in the wagonway, as in this case. If this

had happened, the men at the east and west furnaces would have been burnt. I rather incline to the belief, that the gas in the flues was not thoroughly saturated with air, and on the blowing down of the crossing took up a fresh portion of air, and so produced a continuance of the blast with greater violence. I have never seen the air in the returns in such a state as to give any indication of the presence of gas by the lamp, nor have I received any reports from the men in charge that they have done so. The arching of the flue was in contact with the stone above. The arch of the fire flue is formed of bricks, but I cannot say they are placed edgeways, but I think so. Probably two bricks edgeways. There is a flat brick flooring at the upper flue. The bottom of the flue has a floor, I think of lime and gravel cement. The arch of the wagonway I believe to be formed in the same way as that over the small flue. I have no conception of the weight resting on the crossing at the wagonway. There is an arch stands over the side flues at this crossing. No fire-damp could have burst into the flues. The flues are swept at stated times, but I cannot say how often, or when they were last swept.

Richard Forster Matthews, of South Hetton, viewer, said—I am viewer for South Hetton and Murton Collieries. I have been a viewer sixteen years, and have seen four or five colliery explosions, and have been burnt myself. Since this explosion I was down the pit assisting to get out the bodies. Everything was done that could have been done to save the men. I have seen both pits. I believe the explosion took place in the No. 3 boiler flue. I have not the slightest doubt of that. My opinion is, that there had been a quantity of gas given off by the boiler fire, probably about 3000 or 4000 cubic feet, which had lodged in the flue, between the boiler and the crossing of the north rolley-way, and had been ignited at the boiler fire, and at first, I think the explosion had been slight, but sufficient to blow out the crossing into the rolley-way, and then the whole volume of gas became mixed with the requisite amount of fresh air, causing the ignition of the whole, and hence I account for the explosive force from that point being so much greater. I do not think it possible the gas could have accumulated from the workings into the flue. I think it could not have come from any other place than the boiler fire. I was at first rather surprised at this explosion, but am not so when I have considered the matter. It is of an extra-ordinary description. I have calculated the quantity of gas there might be in the flues, and consider, if as much gunpowder as you can put into a thimble will carry an ounce ball a mile, I see nothing to prevent the

quantity of gas there would be in the flues to do all this mischief. At Murton we ventilate the flue by a hole five inches square, between the travelling-way and the smoke flue, to prevent such an occurrence. I believe that is generally done. I never knew, but have heard of one of these flues blowing up before this below ground. That was at the Felling. All the damage may have been done without any fire-damp from the workings. I have been frequently, years before, in this pit, and there was always a quantity of air in it. I am aware my opinion is somewhat different to that of Messrs. Bell and Richardson as to the mixture of fresh air, that is, I think the great force of the explosion did not take place until the crossing at the north way gave way. My reason is, that the boiler and engine which is close bye is not injured at all. The explosion would be a continuous one. I have seen the arch-way at the crossing, but have not measured it. It could not be made strong enough to resist an explosion. I think part of the explosion went through Davison's engine to the stables, but the main portion went along the north and south rolley-ways. The west end of the flue being open would not ease the violence of the explosion at the crossing.

Thomas Emerson Forster, of Newcastle-upon-Tyne, said—I have been an extensive viewer of collieries thirty-eight years. I have been down this pit, and have examined it very minutely, with a view to ascertain where the explosion took place. There can be no doubt that the explosion took place in the flue of Davison's engine boiler. The cause was the damping of the fire with a large quantity of coals, and the damper being too closely put down, the distillation of gas from these coals oozed through underneath the damper, and filled the flues with explosive gas, too little air being allowed to pass to sweep it away as it was made. I think the flue had filled back from the top of the crossing on the north way to the damper, and then tailed back on the boiler fire and ignited; and then the gas between the damper and the boiler fire would back through the firehole doors and would set fire to the south-east stables. The larger portion of gas between the damper and the crossing would ignite at the same time, and the first thing it would do would be to blow down the crossing. It is quite clear the blast had gone in that direction, because the wall of the crossing on the east side of the north rolleyway was blown down, whilst that on the west side was left partially standing. It is quite impossible the gas could have been generated in the inbye workings and afterwards get into the flues. There is no other source, in my opinion, but the boiler fire from which the gas could

possibly come. In 1847 I was viewer at the Felling, when we had a similar explosion to this underground. I do not think there was any difference in the nature of the explosions, but that at the Felling caused more damage. The flues there were about the same size as they are here. I built the flues in the East Minor Pit in the year 1826, when I was viewer for Hetton Colliery. I came as viewer to the Hetton Collieries in 1824, and was there until 1831, and I have been frequently down them since that time; and I think it is due to Mr. Daglish to say, that the quantity of air going down, and the distribution of it, does him great credit, and has my unqualified approbation. And I further state, that with that circulation of air in this pit it is impossible that the returns can ever be in a dangerous state. I would have considered the pit perfectly safe with a much less quantity of air. It is quite impossible the explosion can have been caused by gunpowder. If the men were killed at such distances with after-damp it would not surprise me, but I think they were killed by the concussion of the explosion. The effect of the after-damp would extend further than the concussion would kill a man. If the air at the bottom of the pit was going north and south at the rate of eight to ten feet per second before the explosion took place, after the explosion had taken place, and its effects were going on, I have no doubt that the air would then be forced at the rate of from 80 to 100 feet per second, and the consequence would be, the air would rush in and carry the after-damp with it, and so kill the men if then alive. That is the reason there is so much damage done to the rolleyway. The ventilation at the Felling at the time of the explosion there was about 60,000 cubic feet per minute, which would be a larger portion of air in proportion to the workings of the colliery than here. There were goaves in the Felling, but it was quite clear that it was not caused by fire-damp. The engine stood 700 yards from the bottom of the shaft, and the flue was level about 350 yards next the engine, and then rose about two inches to the yard to the upcast shaft—the engine being 600 yards from the upcast and 700 from the downcast. It had no ventilation except what it got from the boiler, which was twenty-eight feet long and six feet diameter. I cannot say whether it was a wheel or a flash flue, but think the latter. The boiler was lifted out of its seat and all the steam pipes broken, and 100 yards of the flue was blown down. The flue there was two side walls, and there were flags over the top. The travelling-way was between the coal and the flue, but there was a brick wall next the coal on each side. I would suggest one way of preventing

these explosions—by putting the fires out. The next is by keeping the damper sufficiently high for the current of air to sweep away the gas as soon as made. And a third, by making an opening in the flue wall from the travelling road beyond the damper, and allowing a sufficient quantity of air to go in and so clear the gas away as made. It is my opinion that the gas could not ignite at the west ventilating furnace, and if it had ignited there, the west side of the crossing would have blown down instead of the east. From the evidence I have heard as to the ventilation previous to the explosion, I think the ventilation was quite sufficient, and that it occurred from circumstances that could not be foreseen. I do not consider the damage done so great as might have been expected, independent of the burning of the stables and the sacrifice of life. The masonry of the crossing I consider perfectly strong enough for its purpose, as it has been there thirty-four years.

Richard Heckels, of Bunker Hill Colliery, viewer to the Earl of Durham and others, said—I have been a viewer twenty-two years, and have had charge of extensive collieries. I was down this pit on the morning after the explosion, and every means were used to save the lives of the men in the pit. I have been down the pit, and through the flues, and have examined them four or five times, as well as the neighbourhood of the shaft. The explosion had taken place in the flues at Davison's engine fire, from an accumulation of gas from the fire to the crossing at the north rolleyway, which was generated from the coals put on the furnace fire in damping it, and which got into the flues underneath and at the sides of the damper. I think, whilst it was accumulating, it would fill like a balloon, and tail back through or at the sides of the damper. It would ignite, and pass quietly on underneath, just behind the damper, and explode the gas inside the flue. I think it is barely possible for the gas to have been set on fire at the west ventilating furnaces. The gas could not have accumulated from the workings of the pit, or any other source, to be brought into the flue, than that I have named. With this ventilation there might have been gas in the goaves, but not any in the workings. I have not known of any explosion of this nature before; but since this explosion I have heard of that at the Felling, but know nothing of it of my own knowledge. The ventilation was amply sufficient for the safety of the men. I would have considered it safe with half the ventilation. I consider it the best ventilated pit I have ever seen. I know the Hetton Collieries well,

having served my time there as a viewer for four years, up to August, 1838. It is possible that it may often have been near an explosion during this length of time, and yet not happen. An explosion of this sort requires a certain combination of circumstances, at a certain time, to cause it, all the circumstances meeting together at the same moment of time.

George William Southern, of Chilton Moor, viewer to the Marchioness of Londonderry, said—I have been a viewer fifteen years, and have had the management of extensive collieries. I have been down the Minor Pits, and have particularly examined them. My opinion is, the explosion took place in the flue of No. 3 boiler. There can be no doubt about it. The cause I believe to have been gas in the flue, from the boiler end to the north way crossing. It could not accumulate there from any of the workings of the pit, but had done so from the damping of the fire, the gas being generated from the coals used for that purpose. The gas had tailed back from the flue to the back of the boiler fire, and there ignited, and then communicated underneath the damper with the gas lodged between that point and the crossing; and having blown out the crossing, and then meeting with a strong current of fresh air, caused the explosion to be more violent, and to spread both north and south, and cause the damage done and the loss of life which has been described. I have had a good deal of experience with underground boilers, and it is usual to damp them. Before this explosion took place, I would not have feared damping the fires. This explosion has altered my opinion as to the probability of an explosion. I now think it more probable that it might occur again. I do not think it necessary for the fires to be put out to prevent an explosion. I would think a door from the travelling way into the flue, in connection with the damper, could be constructed so as to let in a supply of fresh air when the fire was damped, so that the damper could not be put down without the door opening at the same time. I have flues underground in my management, but we have not ventilated them. It has not been general in the trade in this district to do so. I would only consider it necessary to ventilate them when the damper was down. If the damper had been high enough to let in a current of air to carry off the gas as made, this explosion would not have occurred. I would not have expected the fireman to have left it further open than was sufficient to carry off the smoke. The raising of the damper, more than sufficient to take off the smoke, would blow up the

fire, and make it burn brighter. The act of cooling down the flues by the admission of fresh air might reduce the temperature in the flue, and make it more liable to explosion by that means than the other.

Edward Sinclair said—I live at Durham, and have been a viewer upwards of twenty-two years, and have had the management of extensive collieries, both in this district and in South Wales, and have seen and investigated many colliery explosions, and was down the pit when an explosion at Springwell took place, when thirty-seven men were killed, I think in the year 1838. I was down the Minor Pit on Saturday morning, and examined the parts. I think the explosion took place in the flue between Davison's engine boiler and the crossing in the north way, from gas collected in the flue between the damper and the crossing; and, I think, when the boiler fire was damped down it would then be similar to an ordinary gas retort, and a constant distillation of the gases, from the coal and coke composing the fire, would be collecting in the flue behind the damper. I imagine it tailed back, either below or at the sides of the damper, and had ignited at the boiler fire, communicating that flame to the gas in the flues, and producing the explosion. I agree with some of the previous witnesses that the explosive force of the gas would be very much increased when the crossing over the north way was blown out, and I think there was quite sufficient force to cause the damage I have seen. I have never known an instance where the boiler flues were ventilated, but do not think there would be any danger in doing so. The air in the flue would be rarefied. By the sudden introduction of cold air, you might damage your flues, but not cause such an explosion as this. But it is, I think, very easy to warm the air by passing it over the boiler, before admitting it to the flues. It is usual, both in this district and Wales and Scotland to damp the fires, and not to ventilate them. I do not know a flue ventilated in any other way than this was. I was down this pit previous to the explosion (about three years ago), and I considered it was then one of the best ventilated pits within my knowledge.

Matthias Dunn, of Newcastle-upon-Tyne, mine inspector from the Tyne to the Tweed, the northern district, said—I attend for Mr. Atkinson, the inspector of this district, in consequence of his illness. I have been fifty years a viewer. I have been down the East Minor Pit once since the explosion, and have examined it. The explosion took place near to the damper in the flues, from gas accumulated there, generated from coal used in damping the boiler fire, which had tailed back from the flue

underneath the damper, and become fired at the back part of the boiler fire, or had formed an explosive current all the way to the west ventilating furnaces, and there taken fire. The gas could not have accumulated in the flue from the workings of the pit. I was viewer of Hetton Colliery, in 1832, and this engine and boiler was then working in the same manner as at the time of the explosion, and I considered it perfectly safe. I do not think any thing could have been done by the parties in charge of this pit to avoid this explosion. I consider this is similar to the explosions of boilers which are so difficult to understand, and cannot satisfactorily be accounted for. I consider it a very peculiar case, and there must have been a peculiar combination of circumstances to have produced it. So that if the flues were erected again in the same way as previous to this explosion, a similar one might not take place for very many years, or it might take place next week. Ventilation of the flues, I consider, desirable, and, I think, it could be done with advantage so as to prevent such an explosion occurring again.

Joseph Dickenson, of Pendleton, near Manchester, mine inspector for the Manchester district, said—At the request of Mr. Atkinson, who is too ill to attend to the matter himself, and by the direction of the Home Secretary, I have attended this enquiry. I have been down the East and West Minor Pits, and have particularly examined them, and have no doubt there has been an explosion in the flue of Davison's boiler, at the part spoken to by the witnesses, between the boiler fire and the north crossing. I cannot say that I have clearly made my mind up from what cause the explosion took place. If it has been from gas in that flue, and in the quantity described, it has been gas of a more violently explosive kind than any I have hitherto met with in coal mines. I have officially investigated upwards of a dozen explosions, and upwards of one hundred killing less than ten persons, and have never met with a case where the gas has been of so explosive a character as it seems to have been in this case, that is judging from the small quantity of gas which we have been able to trace out. Unless it was in a larger quantity than what that portion of the flue would contain, it could not be ordinary fire-damp. This is the only explosion I ever investigated without coming to a conclusion satisfactory to my own mind. I do not think there is the slightest blame to attach to the viewer, or any party connected with the pit for this explosion; for although every witness we could get has been examined and sifted, we have not been able to find that there was any ordinary fire-damp. I feel quite sure that if the explosion was in-

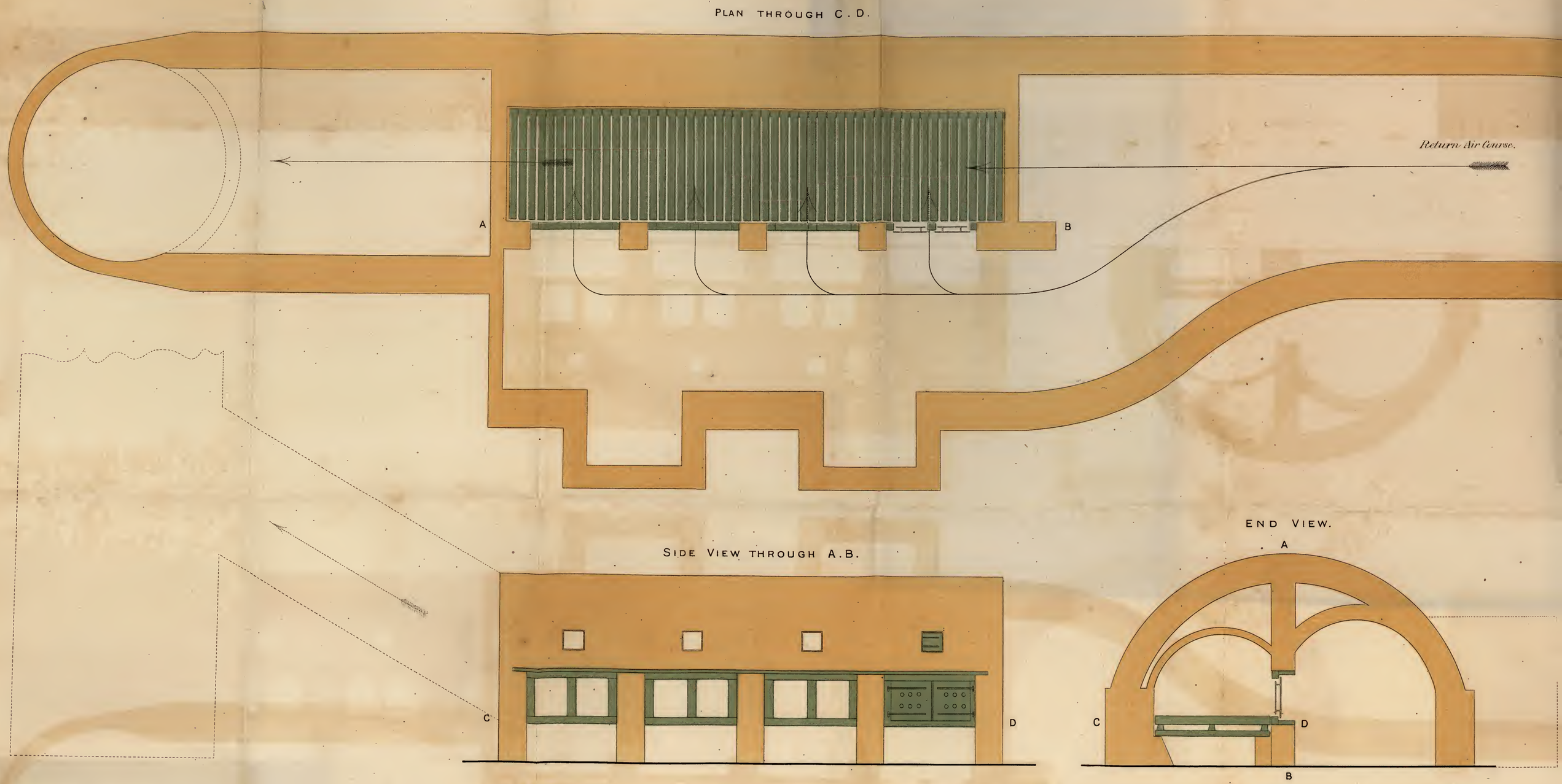
the flue, it could not have its full supply of air, and on knocking the crossing down, it got its requisite quantity from the intake, and a further explosion took place, and then it went right along the level.

The examination of Mr. Dickenson completed the evidence, and the Jury returned the following

Verdict—"That the said John Greaves and twenty-one other persons, on the twentieth day of December, now last past, came to their deaths, in the East and West Minor Pits, Hetton Colliery, in the parish ward and county aforesaid, by an explosion of inflammable gas, accumulated in the flue leading from the boiler fire of Davison's engine to the upcast shaft, which gas was not generated in the workings of the said pits."

Plan of Furnace at Eppleton, Hetton Colliery.

Scale 4 Feet to an Inch.



Lithographed by Andrew Reid, Newcastle.

John Daglish
Hetton Colliery

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ON THE

CONSTRUCTION OF VENTILATING FURNACES.

By Mr. JOHN DAGLISH.

In considering the construction of ventilating furnaces, more especially in reference to the manner in which the supply of air is effected, the question seems capable of being divided into four general principles.

The FIRST PRINCIPLE is as an open fire fed entirely with the return air.

The SECOND PRINCIPLE is by contracting the area for the passage of the air over the fire, and forcing a larger quantity through the bars, thus supplying the incandescent fuel with a larger portion of oxygen in a given time, greatly increasing the quantity of coals consumed, and elevating the temperature in the furnace drift and upcast shaft, but at the same time increasing the drag of the mine with the contraction.

One of these principles, or an intermediate modification, has hitherto been usually adopted in underground ventilating furnaces.

It is, perhaps, impossible to lay down any general rule as to the proportionate area above and below the bars, and that of the side passages, to produce the maximum effect, so much depends on the depth of the shaft, the velocity of the current, the size of the furnace, and the drag of the mine.

Large furnaces are usually fitted up with iron doors, which in some cases close entirely the space above the bars. These are shut partially or entirely, to meet the requirements of the mine. When it is necessary to raise the fire after being first lighted, or after cleaning, these doors are very useful in directing the current of air through the fire; and as the current increases, owing to the increased temperature, they can be opened as required; but the exact point at which the working value of the furnace is highest, can only be ascertained by actual experiment in each particular case.

The following experiment was made at Eppleton Colliery on this point; and it will be observed that, not only was the air increased largely (9,450 cubic feet) in the Upper or Main Coal Seam, when all the Hutton Seam air was forced through the furnace, but that this latter air also increased (9,240 cubic feet), owing to the increased temperature of the upcast shaft, caused by the consumption of double the quantity of coals. It will also be observed that, when all the doors were open, there was still a contraction of nearly 1-10th of an inch of water pressure forcing the air through and over the fire, and that, when the doors were shut, this amounted to 3-10ths.

Experiments made at Eppleton Colliery, with Furnace Doors open and shut. Observations taken every ten minutes.

	Time.	HUTTON SEAM.					MAIN COAL SEAM.					Coals Consumed.	
		Revolutions.	Multiplier for Friction.	Velocity per Minute.	Quantity. Cubic ft. per minute. Area = 50 sq. ft.	Water Guage.	Revolutions.	Multiplier for Friction.	Velocity per Minute.	Quantity. Cubic ft. per minute. Area = 70 sq. ft.	Water Gauge.		
						Inch.					Inch.	¼ Cwts	
DOORS OPEN.	6·00	740	1·05	777	....	2·3	880	1·05	924	....	1·0	6	
	·15	730	1·05	766	....	2·2	850	1·05	892	....	1·0	6	
	·30	730	1·05	766	....	2·1	850	1·05	892	....	1·0	5	
	·45	720	1·05	756	....	2·0	840	1·05	882	....	1·0	7	
	7·00	730	1·05	766	....	2·0	850	1·05	892	....	1·0	5	
	·15	720	1·05	756	....	2·1	850	1·05	892	....	·9	4	
	·30	745	1·05	782	....	2·0	850	1·05	892	....	1·1	4	
	·45	730	1·05	766	....	2·0	850	1·05	892	....	1·2	5	
	8·00	730	1·05	766	....	2·0	860	1·05	903	....	1·2	..	Cwts.
	Aver.	731	1·05	767	61,360		850	1·05	892	62,440		42	= 10½
DOORS SHUT.	9·00	800	1·05	840	....	2·1	860	1·05	903	....	1·3	6	
	·15	820	1·05	861	....	2·4	900	1·05	945	....	1·3	7	
	·30	840	1·05	882	....	2·4	990	1·05	1039	....	1·3	8	
	·45	840	1·05	882	....	2·6	1050	1·03	1081	....	1·3	8	
	10·00	850	1·05	892	....	2·5	1000	1·05	1050	....	1·3	7	
	·15	880	1·05	924	....	2·7	1020	1·03	1050	....	1·3	11	
	·30	875	1·05	919	....	2·7	1040	1·03	1071	....	1·3	11	
	·45	870	1·05	913	....	2·7	1020	1·03	1050	....	1·3	12	
	11·00	875	1·05	919	....	2·6	1020	1·03	1050	....	1·3	8	
	Aver.	853	1·05	895	71,600		988	1·04	1027	71,890		78	= 19½
	Increase				9,240					9,450			

Water Guage on Iron Door into Furnace Drift.

·09 with all the doors open.

·18 with old furnace doors shut.

·30 with all the doors shut.

A similar experiment was made at Elemore Colliery; in this case, with the *doors open*, the quantity in the Hutton Seam, in which the furnaces were placed, was 46,596 cubic feet, and in the Upper or Low Main Seam 21,145, with a consumption of $6\frac{1}{4}$ cwts. of coals; and with the *doors shut*, 47,775 cubic feet in the Hutton Seam, and 23,420 in the Low Main, and a consumption of double the quantity of coals. During the experiments the furnaces were not driven hard, but, as nearly as possible, an equal amount of fuel kept on the fire during the whole time.

Experiments made at Elemore Colliery, with Furnace Doors open and shut.

	Time.	HUTTON SEAM.					LOW MAIN SEAM.					Coals consumed.	
		Revolutions.	Multiplier for Friction.	Velocity per Min.	Quantity. Cubic ft. per Min. Area = 65 sq. ft.	Water Gauge.	Revolutions.	Multiplier for Friction.	Velocity per Min.	Quantity. Cubic ft. per Min. Area = 32 sq. ft.	Water Gauge.		
						Inch.					Inch.	½ Cwts	
DOORS OPEN.	4·30	650	1·10	715	46,475	1·3	570	1·12	638	20,428	1·0		
	·45	660	1·10	726	47,190	1·2	570	1·12	658	20,428	1·0	1½	
	5·00	665	1·10	731	47,515	1·2	570	1·12	638	20,428	1·0	1½	
	·15	665	1·10	731	47,515	1·2	600	1·10	660	21,120	1·0	2	
	·30	655	1·10	720	46,800	1·2	590	1·11	654	20,928	1·0	1½	
	·45	650	1·10	715	46,475	1·3	590	1·11	654	20,928	1·0	1½	
	6·00	625	1·10	687	44,655	1·2	640	1·09	697	22,304	1·0	1½	
	·15	647	1·10	712	46,280	1·2	630	1·09	686	21,952	1·0	1½	
	·30	650	1·10	715	46,475	1·2	625	1·09	681	21,792	1·0	1½	Cwts.
		652		727	46,596		598		657	21,145		12½	= 6¼
DOORS SHUT.	7·00	665	1·10	731	47,515	1·3	650	1·08	702	22,464	1·05	3	
	·15	685	1·10	753	48,945	1·3	660	1·08	712	22,784	1·10	1½	
	·30	680	1·10	748	48,620	1·3	660	1·08	712	22,784	1·10	2	
	·45	660	1·10	726	47,190	1·2	685	1·07	732	23,424	1·10	3	
	8·00	650	1·10	715	46,475	1·2	685	1·07	732	23,424	1·10	2	
	·15	665	1·10	731	47,515	1·3	705	1·06	747	23,904	1·15	4	
	·30	670	1·10	737	47,905	1·3	700	1·06	742	23,744	1·20	2	
	·45	660	1·10	726	47,190	1·3	700	1·06	742	23,744	1·20	3	
	9·00	680	1·10	748	48,620	1·3	730	1·05	766	24,512	1·20	2½	Cwts.
		668		735	47,775		686		731	23,420		23	= 11½
	Increase				1,179					2,275			

Water Gauge on Iron Door into Furnace Drift.

·14 with furnace doors open.

·35 with furnace doors shut.

In cases where more than one seam is worked, or where the currents pass into the shaft at different points, by placing the furnace in that seam or current, which either from having the shortest run or other cause can bear the greatest resistance, and by passing the whole or greater part *through* the bars, a higher temperature can be obtained, without injury to this current, and yielding the full benefit to the other splits.

At Eppleton Colliery the distance travelled by the air underground in the Lower or Hutton seam, is so much greater than in the Upper or Main Coal Seam, that a great contraction is required in the Upper Seam to apportion correctly the currents. Under these circumstances a furnace could have been placed in the Main Coal and a large portion of the air forced through the fire without injuring the ventilation of this seam. Advantage has been taken of this to feed the engine boiler fires with the return instead of fresh air; by this means the shaft resistance on the quantity of fresh air, which would otherwise have been required for this purpose, is saved. I would here mention, however, that a boiler fire does not yield equally good results as a ventilating power, with a well-arranged furnace. Not only is a very large portion of the heat of the former absorbed by the water in the boiler, a great portion of which is ultimately dissipated, but the cooling surface of the boiler prevents the proper combustion of the fuel, and large quantities of smoke are formed. Again, the action is very irregular, the firing being either very violent when steam is required, or, absolutely nil when the engine is not working, when generally speaking, the dampers are closed so as almost to stop combustion.

The THIRD PRINCIPLE is by feeding the furnace with fresh air, which permits of a strong blast, without adding to the drag of the mine. As this method has been so fully and ably treated by Mr. Armstrong, in a recent paper, I will only mention what seems to me to be obstacles to its general adoption.

First.—The great wear and tear consequent on the very high temperature in the furnace.

Second.—When a strong blast is passed *through* incandescent fuel and none *over* it a large portion of the carbon passes off as carbonic oxide, without combining with its maximum quantity of oxygen. Muspratt states the loss at the Alfreton Blast Furnaces to be 81 per cent. of the fuel consumed, and gives the following as an average analysis of the mixed gases passing off:—

Nitrogen - - - -	60·907	to	57·878
Carb. Acid - - - -	8·370	to	9·230
Carb. Oxide - - - -	26·846	to	24·042
Carb. Hyd. - - - -	2·536	to	2·743
Bi-carb. Hyd. - - -	·112	to	·392
Hydrogen - - - -	1·126	to	4·972
Sulph. Hyd. - - - -	·045	to	·035
Ammonia - - - -	·058	to	·115

Third.—In case of limited shaft room—that is when the quantity of air passing up an upcast shaft is already so large as to require a velocity of say thirty feet per second—the addition to it by admitting fresh air to the furnace, of any quantity not available for the special purposes of ventilation, is a serious question. For as this increased quantity will cause an increased resistance in the shaft, a proportionate increase of temperature will be required, which will not only necessitate a largely increased consumption of fuel, but will magnify one of the most serious objections to the use of the furnace at all, viz., the injurious action and effects of the furnace vapour and furnace heat, especially at elevated temperatures.

There remains a FOURTH PRINCIPLE, or rather a modification of the second. This is to increase largely the area of fire grate, so as to afford extended surface for contact of oxygen with the incandescent fuel, without adding to the resistance. For it must be borne in mind that unless the air is brought into actual contact with the burning fuel or gases, it is valueless for the purpose of increasing or supporting combustion.

If all the air is forced *through* the fire, a portion of the fuel will pass off as carbonic oxide as before mentioned, also the drag of the mine will be greatly increased; on the other hand, if too large a quantity of air is passed *over* the fire, its cooling powers will prevent the proper oxidation of the hydro-carbon gases, which requires a high temperature, and the formation of smoke will detract from the full value of the coal used, further combustion will be feeble, and a high temperature in the shaft will not be attained. By having a large surface of fire grate, and using a thin fire, thus reducing the resistance, and by allowing such a quantity of air to pass over the fire as is just sufficient thoroughly to saturate the resultant gases with oxygen, and cause perfect combustion without reducing the temperature, the maximum effect will be obtained. A furnace on this principle has been erected at Eppleton Colliery, and has given very satisfactory results. It is twenty-six feet long by six feet wide

(one-hundred and fifty-six square feet), and, as will be seen on the accompanying plan, all the air which passes over the fire, passes along the entire length of twenty-six feet, thus supplying the oxygen necessary for the consumption of the gases at an elevated temperature, and, consequently, preventing the formation of smoke.

The advantages offered by this form of furnace, are :—

1.—*Economy of construction.*

2.—*Elasticity of action.*—One, two, or more fires can be in operation together.

3.—*Continuance of action.*—There being no check when cleaning as in ordinary furnaces, this being always in operation by moving the fire from one end.

4.—*Consumption of smoke.*

5.—*Absence of radiated heat,* and coolness of passages, &c., near furnace.

6.—*Capability of extension* to any size, to meet the requirements of the mine.

There can be little doubt that the best position of the furnace, as a ventilating power, is as near the bottom of the upcast as possible; but, when the shaft contains any wooden material, especially brattice or guides, it is necessary to place it at such a distance as to remove all possibility of any sparks reaching the shaft. If this is done by sinking a staple at the furnace, some distance upwards, and connecting it at the top by a drift with the shaft, there will be little loss of ventilating power. It is necessary, however, to take into consideration the possibility of wood becoming inflamed without actual contact with ignited matter. At a colliery in this district, the furnace, which is in the Hutton Seam, is placed close to the bottom of a staple sunk up to the Main Coal, a distance of thirty fathoms, and connected at the top by a drift of twenty-five yards with the upcast. Frequent observations have been made to detect sparks at the top of this staple, when the furnace was hard driven, and portions of tar-barrels have been placed on the fire and then stirred to make the sparks pass freely off, and none could ever be observed at the top; but the fine dust in the drift into the upcast, wherever it could accumulate to a depth of a few inches, was always red hot. Again, during the recent fire in Hetton Colliery, resulting from the explosion, a wood stopping was built across the wagonway in which the fire was; this was so warped and injured by the great heat that a brick stopping was built in behind it, and shortly after this was done the wood

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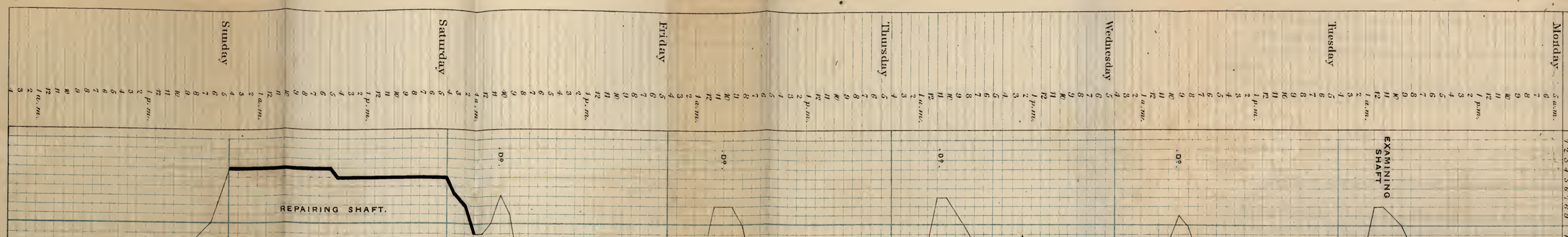
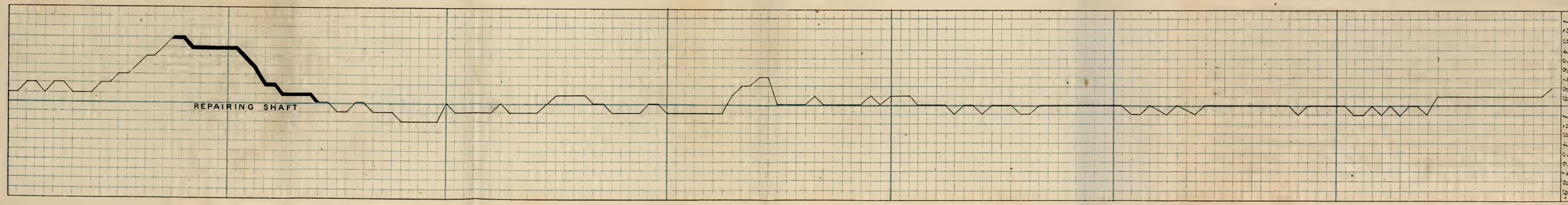
Diagrams of Ventilating Pressures as shewn by the Water Guage.

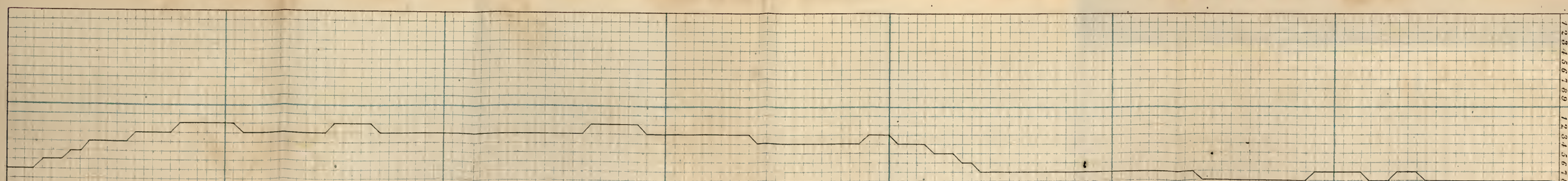
A. Wet Bratticed Shaft.



B. Ellmore Colliery.



C. Eppleton Colliery.



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Lithographed by Andrew Reid, Newcastle

John Daglish
Hetton Colliery

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A. Wet B

stopping took fire, although it was 100 yards from the fire in the coal. Further, the soot adhering to the sides, or lodging on ledges, is frequently observed to be on fire in upcast shafts, where a high temperature is kept up. This militates against another advantage offered by feeding the furnace with fresh air. It is a question for very serious consideration whether, knowing the liability of fire in upcast shafts, it is advisable to pass the return air into the shaft without passing over the furnace—whether this supposed security might not lead to allowing the return to be charged with gas to an extent which *could not* be allowed if it had to pass over the furnace, and the same amount of fresh air which would be required in the former case to feed the furnace, might, in the latter case, be made available for further diluting the return air.

But whilst allowing the advantage offered by placing the furnace close to the bottom of the upcast shaft, as the best means of attaining the maximum effect from a given quantity of coal, there are also advantages of another kind attained by placing the furnace at some distance. When the furnace is in the first position, and the upcast shaft is wet, as, for instance, in a bratticed shaft, where it is absolutely necessary to allow a quantity of water to pass down—on occasions when the shaft requires repairs, and the furnace is put out, or damped down sufficiently to enable the men to work, then there is very little reserved heat, and the temperature falls rapidly. The ventilating power of a furnace so placed and circumstanced ceases almost with its action; whilst in cases where a quantity of heat is conserved in a considerable length of furnace drift, dry staple, or engine flue, not only does heat continue to be given off for a considerable time after the furnace is put out, but, during its active state, the ventilating pressure is less fluctuating.

The annexed diagrams of ventilating pressures, as recorded by the water gauge, will shew this:—

A. is a water gauge diagram, taken every hour for one week, in a bratticed upcast shaft where a large quantity of water was conducted down the brattice and slides. It will be observed, that every night from ten to eleven, the water-gauge fell rapidly during the time that the men were engaged in examining the shaft, and, that on the "Pay Saturday" when repairs were being executed, the pressure fell rapidly to about $\frac{6}{10}$ at which it remained pretty regular, this being little above the natural ventilation of the mine.

B. and C. are water-gauge diagrams of Eppleton and Elemore Collieries, at both of which there are considerable lengths of engine flue.

It will be observed that the ventilating pressure is almost constant and steady, and, that when the shaft was being repaired on the "Pay Saturday" (B.) the pressure fell slowly and gradually.

At Eppleton Colliery, after the furnaces and engine boiler fires had been out above a month, the temperature in the coolers or travelling ways on each side of the flue was 104°, and during the whole of this time from 5,000 to 10,000 cubic feet per minute had been passing along.

NORTH OF ENGLAND INSTITUTE
OF
MINING ENGINEERS.

GENERAL MEETING, THURSDAY, APRIL 18, 1861, IN THE ROOMS OF THE INSTITUTE, WESTGATE STREET, NEWCASTLE-UPON-TYNE.

NICHOLAS WOOD, ESQ., PRESIDENT OF THE INSTITUTE, IN THE CHAIR.

The SECRETARY having read the minutes of the Council meetings of the 6th and 18th inst.,

The PRESIDENT said, relative to the Birmingham meeting, it had been thought advisable that Mr. Woodhouse, Mr. Blackwell, Mr. Smith, Mr. Binns, Mr. Matthews, and Mr. Marshall, being resident in the Midland district, should be added to the committee. He (the President) had met some of these gentlemen in London last week, when they agreed to act on the committee. Mr. Smith stated that he would be very glad to light up the caverns under Dudley Castle, which would be a very great treat indeed, exceeding even a visit to the far-famed caves of Kentucky.—The next subject on the minutes of the Council was in reference to the interview with Dr. Charlton and the deputation from the Natural History Society. The meeting would no doubt approve of what the Council proposed, which was, that the Institute would be glad to coöperate with the Natural History Society to have a joint museum, each Society, however, keeping its own property distinct, but having the specimens so arranged that the public might see them to the best advantage. The Institute would thus save the expense of having a curator. The Council proposed to appoint a committee to coöperate with a committee of the Natural History Society, to make the necessary arrangements.

Mr. BERKLEY asked if it were possible to get a distinct room or part of a room, so as to prevent the two museums being mixed together.

Mr. Hall said, they might very easily connect their own room with that of the Natural History Society by a platform.

The President said, they might give instructions to the committee to keep in view the principle of securing to the Institute the specimens as their property, by keeping them distinct from the specimens of the Natural History Society, and that, he considered, would be all that was requisite.

The following resolution was then adopted unanimously:—"That a committee be appointed to confer with the committee of the Natural History Society, for the purpose of making some arrangements for the mutual exhibition of the specimens, minerals, models, &c., of each Institute, that the committee report to the Institute the result of their conference; and that the President, with Messrs. Reid, Daglish, and Berkley, form such committee."

The following gentlemen were then elected members of the Institute:—Mr. T. H. Murray, Chester-le-Street; Mr. Philip Matthews, Leasowes, Birmingham; and Mr. Archibald Hood, Whitehill Colliery, Lasswade, by Edinburgh.

The President said it was his painful duty to communicate to them the irreparable loss which the Institute had sustained in the death of one of their Vice-Presidents, the late Mr. Thos. John Taylor. It was unnecessary for him to say one word as to the services which that gentleman had rendered to the Institute, and the loss which not only they, but every individual member of the Coal Trade had sustained by his death. It had been his intention, as it was in the case of the late Mr. R. Stephenson and Mr. Locke, to have said a few words on Mr. Taylor's career in life, and more particularly what he had done for this Institute, and for the Coal Trade at large; he had not, however, had time to do so before this meeting, but he hoped at the June meeting to lay before them a few observations on the services of one to whom the Institute owed such a deep debt of gratitude.

DISCUSSION ON MR. WATSON'S PAPER.

Mr. Watson said, since our last general meeting I have made some few experiments upon one of the blocks similar to those now before you, which are as follow:—

The dimensions of one block is twenty-four inches long, twelve inches

high, and ten inches thick, weighing 1 cwt. 3 qrs. 7 lbs., which I placed in a drying stove heated to 250 degrees, for the purpose of ascertaining what change it might undergo, having had an impression that it might expand and crack. After having been in that temperature six hours, I had it drawn out and gauged again, but was unable to detect any alteration in its dimensions, or in any way affected from the extra temperature to which it was exposed, which certainly is so far in favour of cement over iron, which is known to be very susceptible to change of temperature.

Other experiments I made with three small blocks, now produced, weighing respectively 15 oz. 6¼ drachms, 15 oz. 6 drachms, and 15 oz. 1½ drachm, in solutions, for the purpose of trying the effect upon the composition, and ascertaining what loss (if any) there might arise. The results are as follow :—

Solutions.	Time Immersed. Hours.	Weight before put into Solution.	Weight after being taken out of Solution.	Loss per Cent.
		oz. drach.	oz. drach.	
¼ lb. sulphate of iron to 1 pint of water	95	15 6¼	15 4	1·782
Iron rust		15 6	15 4	1·587
1 lb. pyrites, or coal brasses, to pint of do.		15 1½	15 1	0·407
Sulphuric acid, 1 to 2 of water	96	1·465	1·440	2·64

I shall be glad if, from the above results, any discussion may be brought about that may tend to the adoption of improvements in the better securing of mining property generally.

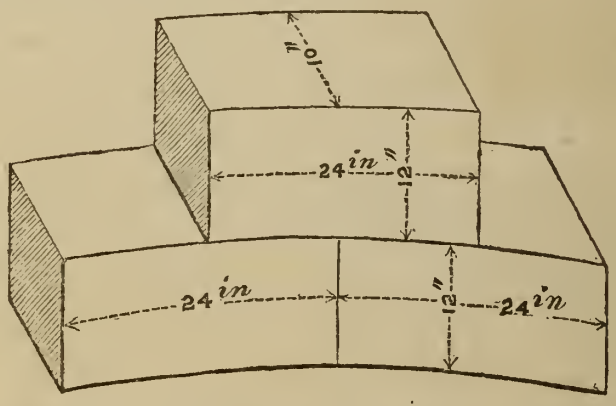
In laying down floors in workmen's cottages, cement would, I am of opinion, be preferable to what is generally used, viz., bricks or flags. The cost is equally as cheap, and certainly more durable; being (as previously stated) impervious to water, it naturally will preclude the damp below rising up through the floor, to the injury of the health of the occupant, particularly where the dwellings are placed in a low situation. From its hard qualifications, rats or mice are unable to make their way through it, consequently such application to a damp cellar or pantry would be a complete preventative attained at a small cost.

Mr. Johnson then read the following supplementary paper on the subject, saying that one of the properties of the cement was its power of not expanding by the degree of heat to which it would be subjected in coal mine shafts :—

For some years I have thought that Portland cement might be judiciously and advantageously employed in the formation of segmental walling stones for lining the shafts of coal and other mines. This idea was founded on the knowledge of the superiority of cement, in some particulars at least, as compared with the ordinary building stone.

My notion was, that the cement stones should be used in such situations where quarried stones are usually employed. Were this only to be carried out in the formation of new shafts or in the alteration of old ones, I have reason to believe that such works, so constructed, would give great satisfaction to all concerned in them, by reason of their soundness and durability.

The following sketch is intended to represent three blocks in position, moulded to suit a shaft of 14 feet in diameter. Each of these blocks have a piece of bent iron cast in the upper side, whereby it can be safely attached to a pulley rope, and conveniently lowered into its place. Each of these masses weighs a little more than one cwt.



Mr. Watson, however, with whom I have had some conversation on the subject, and whose greater knowledge of the appliances necessary in mining operations generally, qualifies him to form an opinion, conceived the original idea that, in addition to what I suggest, the cement blocks would be of great use in superseding iron tubbing. That some material for this purpose is at the present time a desideratum, is apparent to all who take even the most superficial interest in this subject.

As Mr. Watson's paper is to be discussed at this meeting, I thought it would, perhaps, in some measure assist in forming data for observations, if I gave in this supplementary paper an account of a few experiments, together with their results, which I have made and ascertained, for the purpose of proving the fact above stated, that in some respects cement is superior to stone.

First, in its greater density, and consequent lesser porosity.

I made cubes of one inch, both of cement and of the soundest kind of

building stone. These were accurately weighed and immersed in water, and remained there until all minute surrounding air bubbles had disappeared. The pieces were then taken out of the water, the surface water removed with a cloth, and then re-weighed. The results were as follow :—

	Stone. Grains.		Cement. Grains.
After immersion	506·8	....	499·1
Before ,, ...	481·	....	496·3
	25·8		2·8

By which it appears that the stone had absorbed 5·36 per cent., whilst the cement had taken up only 0·56 per cent. This property of non-absorbence appears to me to be exceedingly important, as giving greater durability; for it is a well-known fact that many of the building stones become disintegrated, in consequence of moisture entering the pores, which subsequent frost converts into ice in winter, causing rupture by expansion.

It is true that, in mines where the temperature is, as I suppose, always above freezing point, disintegration cannot take place from this cause; yet non-porosity of material employed here is an advantage in other respects, inasmuch as mineral waters cannot permeate the substance, thereby confining their action to the surface.

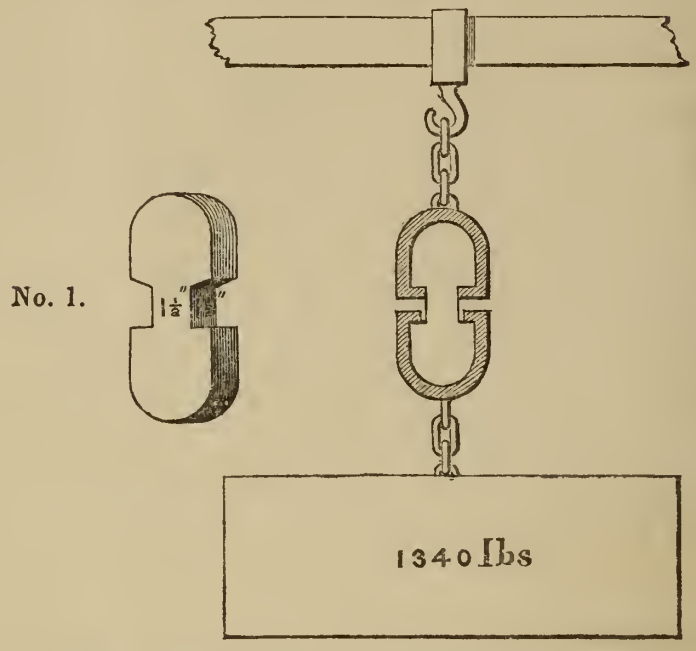
Second, the property possessed by cement of resisting pressure.

Cubes of one inch, both of stone and cement, were made, and placed under a crushing lever. The stone was crushed to powder with a pressure of seventeen cwts. The cement cubes, which had been moulded only a few days, bore a pressure of twenty-one cwts., and would have borne a great deal more had the trial been postponed to give them greater age. It is evident, therefore, that the blocks are capable of sustaining a pressure in any direction of more than 2000 lbs. on the square inch—considerably more than can be sustained by natural stone. This property also must recommend it for mining purposes, where weight and pressure come into play.

Third, I notice its power to resist strain. The particles of which the cement is composed are held together by the force of chemical attraction in a remarkable manner, and this property seems to increase with age. The following experiment will show the comparative merits of stone and cement in this respect. Notched bricks, as shown in sketch No. 1., were made both of the former and latter material. These were put into

iron cramps (sketch No. 2), and suspended in such a manner as that the strain should be applied to the central section of $1\frac{1}{2} \times 1\frac{1}{2}$, or area of two and a quarter square inches.

No 2.



The stone broke with 560 lbs. suspended to it: the cement required no less a weight than 1340 lbs. to tear it asunder.

Stone - - - -	248 lbs.	per	square inch.
Cement - - -	595 „	„	„

Another property possessed by the cement is that of hydraulicity, or its power to resist the solvent action of water. These cubes were immersed in water immediately after having been made, and so far from that liquid dissolving them, or acting injuriously in any other way, it tended only to harden them. All persons who have paid attention to this subject, are aware that the Portland cement becomes a great deal harder by being exposed to damp or wet situations. This was proved on a large scale at the harbour works at Dover and at Alderney, where blocks from three to four tons weight were made, composed of from seven to eight parts of shingle and rubble stone to one part of cement, and these blocks were exposed for the space of two years to the constant action of the sea, and the only effect produced was that of induration. The same thing was done at the harbour works at Cherbourg, and with the same satisfactory results. This property, therefore, of perfectly resisting the chemical and mechanical action of water, I think, renders Portland cement preëminently suitable for mining works, where this element has to be contended with.

Portland cement is also capable of resisting alternations of temperature through a very considerable range—from the most severe frost to 420 degrees of Fahrenheit. I cannot say how much farther; but I have put it to this test:—By placing bricks made of it into a suitable oven, having an opening through the top into which a chemical thermometer was fixed, the mercury stood at 420 degrees for several hours. The bricks were then brought out suddenly into an atmosphere of 60 degrees without sustaining the least injury. One of the large segments, also, as sketched at the beginning of this paper, was introduced into a large drying oven at a temperature of 250 degrees, and remained there several hours for the purpose of ascertaining whether or not contraction or expansion to any extent would be produced. To arrive at a proper conclusion on this point, suitable iron gauges were made, indicating the exact length, breadth, and thickness of the block. These were applied before putting the block into the chamber. After it had been there several hours, and, consequently, exceedingly hot, and again when withdrawn and thoroughly cooled, under all these circumstances, no appreciable difference in the size could be detected, and the soundness of the mass was not in the slightest degree interfered with.

Taking these matters into consideration, I cannot help thinking that gentlemen having the conducting of mining operations under their superintendence, will come to the conclusion that, at least, the matter is worthy of being submitted to the test of actual experiment, practically and on a large scale; the more so, when they consider that it is now the custom to line iron ships with this material, in order to preserve the rivets and plates from the action of bilge water or other matters that may proceed from cargo, such as molasses, &c. The lower reservoirs of gasometers, which were originally made of iron, are now chiefly constructed of this material.

The PRESIDENT inquired if, in the experiment, there was no expansion whatever.

Mr. JOHNSON said, it was not perceptible to the gauges.

Mr. WATSON said, he tried them with hoop iron, and marked them as accurately as he could.

Mr. DAGLISH said, he was afraid there was not a sufficiently large surface to detect the expansion. They had a higher temperature than 400 degrees in an upcast shaft.

Mr. WATSON said he would get a larger piece—four or five times the

size—and submit it to a more severe heat, and ascertain the fact indisputably.

The PRESIDENT said, the cement might, perhaps, form a substitute for stone, but it was another matter to substitute it for iron tubbing in shafts. As he understood the mode of using the blocks, it was not intended to wedge the joints, but to bed them, by means of the same cement, in the ordinary manner. In that case, very much depended on the material always presenting precisely the same dimensions. If there was any contraction or expansion whatever, it would loosen the joints, and would thus become useless as tubbing.

Mr. WATSON said, there were no joints in it: it formed one mass when properly bedded.

The PRESIDENT said, he was afraid that would not meet the objection, because there would be a larger area to operate on, by the expansion or contraction.

Mr. BELL said, he apprehended there would be a much greater difficulty than the purely mechanical one, and that was the chemical. It was evidently an earthy matter. It was probably not sulphate of lime, if it had been decomposed by sulphuric acid. It must be a compound of lime and some other substance, held together by some force which was less powerful than that which existed between sulphuric acid and lime. All other compounds of lime, with one exception, possibly were liable to decomposition from sulphurous acid. This exception was oxalate of lime; and he was afraid oxalic acid was too precious to be used in the composition of Portland cement. The result would be this, that in the upcast shaft, by reason of the temperature and the presence of moisture, the cement would ultimately be converted into sulphate of lime. He did not know how this cement was composed, but he knew that from 400 to 600 parts of water were capable of dissolving one part of sulphate of lime or plaster of Paris. However effectual Portland cement might be in the beginning, he had had too much experience as to the exposure of lime and its compounds to the action of decomposing agents, to believe that it could be of any utility as a substitute for tubbing.

The PRESIDENT—Mr. Watson admitted that, on putting it into sulphuric acid, two per cent. was dissolved in ninety-six hours.

Mr. BELL—Then, if two per cent. went in ninety-six hours, how soon would the whole of it be dissolved?

The PRESIDENT—They knew from experience that the water running down a shaft was highly sulphureous, and probably at a temperature of

150 or 200 degrees; so that, he feared, the cement would ultimately be dissolved. He thought it might be useful as a substitute for stone in downcast shafts.

Mr. Bell said, nothing was more fallacious than to suppose that, by a single experiment, they could determine the action of these materials on one another. He instanced, as a case in point, a trial he had made of brick instead of lead as a surface for apparatus connected with sulphuric chambers. From certain experiments he was led to think that brick would resist the action of the acid; but all the conditions were not ascertained till the apparatus was erected, and in three months the whole thing was about their ears.

Mr. Atkinson observed, that 2000 lbs. to the square inch was stated as the crushing force. In a pit of fourteen feet in diameter, 100 fathoms of water pressure would crush blocks eleven inches thick, so that at the very least it should be three feet on the bed under such conditions.

Mr. Johnson inquired what was the resisting force of cast iron?

Mr. Atkinson—82,000 lbs. to the square inch, for the weakest, and 145,000 lbs. for the strongest kinds of iron.

The President said, it appeared to him it could only be applied with moderate degrees of pressure, and as a substitute for stone.

Mr. Johnson remarked, that he had not himself proposed substituting it for iron tubbing.

Mr. Dunn—Suppose it were to leak?

Mr. Johnson—You must wedge it, as you do with iron tubbing.

Mr. Daglish was afraid it would not stand wedging.

The President—Mr. Reid had mentioned, in the original discussion, that similar material was used in Prussia to tub back water. His (the President's) knowledge of the use of cement in that country was, that it was confined to very small depths. It was used in passing through the tertiary strata above the coal measures, extending from ten to about twenty fathoms in depth from the surface, and was very thick.

Mr. Reid—Wherever walling was used in Prussia, it was cement. His assumption was, that the water tank trass of the Rhine was the same as this. It was laid twenty-two inches thick.

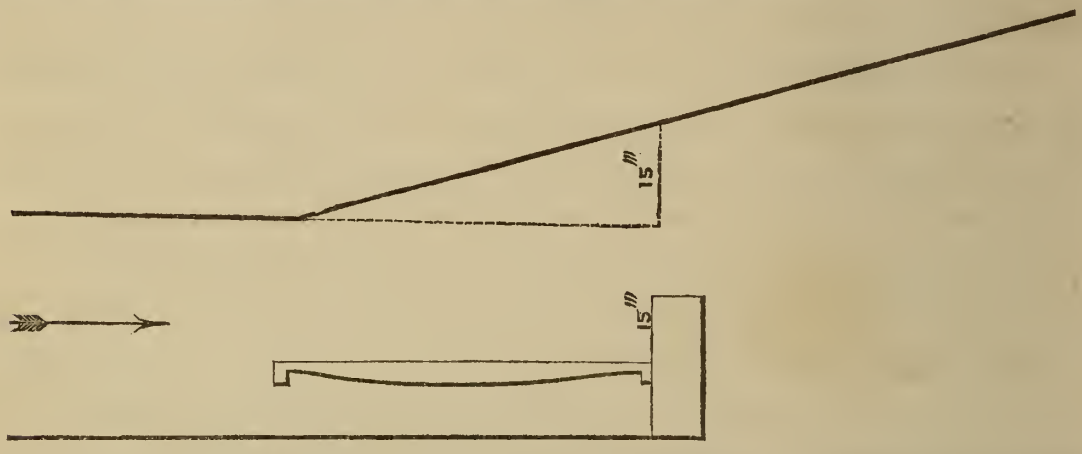
DISCUSSION ON MR. ARMSTRONG'S PAPER.

The President expressed regret that Mr. Armstrong was not present.

Mr. Berkley said, Mr. Greenwell, who could not be present, had sent a few remarks on Mr. Armstrong's paper, which he would read.

Page 75.—Furnaces, as generally constructed, are capable of at least one great improvement, namely, in the area over the bridge at the furnace back. It is clear that if the bars from front to back are laid level, and that if the roof of the furnace from front to back is also level, the area of the passage at the back of the furnace must be diminished from what it is at the front, by whatever the area of the bridge is above the level of the bars.

In order, therefore, to have the same space above the bridge that there is at the front of the furnace, the roof should rise from front to back, as much as the height of the bridge above the bars, thus: —



Page 77, III.—I submit that if it be desirable to overcome the difficulty previously referred to ("in cases of sudden emergency"), of looking to a furnace, under ordinary conditions, for any material augmentation of its power, the first of the true principles for securing the most efficient action of a furnace is *not* to *maintain* as high a temperature as possible in the upcast shaft, but to have the means, in such cases, of as suddenly raising the temperature of the shaft, in order to meet the necessity of the case.

Page 78.—I do not think that "when the upcast is but one section of a large and single pit," it is necessary or even advisable that the brattice alluded to should be of wood, nor consequently that, on this account, it should be absolutely necessary that the furnace should be set back. It is very easy to construct a brattice of brick, the adoption of which plan would, as an additional recommendation to it, have prevented many accidents, some attended by fatal consequences. The writer has recently completed one of 120 fathoms in a 10½ feet pit, the thickness of the work being four and a half inches. In this case there are oak buntings at every six feet, nine inches deep and four and a half inches thick, set edgwise, with a stringing down each angle, composed of half of a nine-inch batten. The pit is walled with brick from top to bottom.

If the oak of the buntings be objected to, they may be made of cast iron, and set farther apart, although the object of these buntings is more to tie the work than to carry the work.

If, as hereafter referred to, iron be inapplicable, arches in the brick-work may be turned at intervals (though thus the advantage of the tie is lost), except it be in the case of quarter bratticing.

The lower part of the brattice should be constructed with fire-brick.

The proximity of a furnace to a drawing shaft is, however, objectionable in another point of view, on account of its action on the guides and ropes, although, since the introduction of wire for these purposes, the objection (as stated farther on in the text) loses much of its force.

It should also be remembered that, with a brick brattice, "the water which is distributed over the surface of the brattice" is no longer required to be so distributed, and consequently will cease to be scattered over the area of the shaft, and to counteract the upward draught and rob it of its heat; and, moreover, a brick brattice, set with perforated bricks and cement or good lime, can be put in without any of those numerous crevices which let in the cold air.

If an objection be taken to the thickness of four and a half inches, a brick brattice may be put in six inches thick with bricks made specially, or nine inches with common-sized bricks; and as to the depth of pit where it is applicable, I am acquainted with an instance of its use, without buntings but with arches, in a pit 240 fathoms in depth.

Page 78.—The full cause of the rapid loss of temperature in upcast shafts has not, I think, ever been clearly shown; and I merely throw it out as an idea, that all the temperature possessed either by air or anything else at any given time, may simply be due to a development of its own latent heat, consequent upon some exciting cause.

Page 79.—I am unable to see how "a malleable iron brattice, built of plates, rivetted boiler fashion, &c.," is compatible with "the destructive action upon all the metal exposed in the pit;" and I should also fear that the conducting power of the sheet iron brattice would operate much against the high temperature of the upcast column, previously so properly insisted on by the author of the paper under discussion.

Page 79.—The setting back of the shaft tubbing, so as to allow of a lining of fire-brick, is now frequently adopted, and is most advisable in upcast shafts. I question, however, whether the action of the furnace upon the tubbing is attributable to temperature: I rather incline to the supposition that it is the sulphurous acid from the coal burnt, and

therefore think that the introduction of the furnace staple as regards the tubbing (supposed to be in the pit only towards the top), would be of little use.

Pages 80 and 81.—The plan of feeding furnaces with fresh air, especially in fiery collieries, is gradually gaining ground, and in order to do this most efficiently, the desideratum is to send into the upcast shaft a small quantity of air at a high temperature.

It occurs to me that, instead of this passing over or through a furnace of ordinary dimensions, and thence into the large upcast beneath the exit of the return air into the shaft, the application of three or four small wind furnaces, kept at a heat sufficient to melt metal, might be a suitable mode of application; and I would propose that, instead of the air passing direct into the upcast, it should pass up a small staple or chimney, so limited as to allow the air in its hottest possible state to pass into the return current immediately before passing into the shaft. These furnaces should be fed with coke.

I draw this idea from Mr. Armstrong's description of Mr. Greener's furnaces at Pemberton.

Mr. Atkinson also submitted some remarks in writing, which were as follow:—

At page 81, Mr. Armstrong states, "With a furnace of these small dimensions, the maximum consumption upon the old plan was four tons of coal in the twenty-four hours; whilst the simple introduction of fresh air through a small pipe with retaining doors, required seven tons to support the waste of coal, with an improvement besides in the working current of 9 per cent. upon equal quantities of fuel." I would remark in general that, other things being the same, the only mode in which a current of fresh air, taken directly from the shaft to a ventilating furnace, can possibly have the effect of causing an additional quantity of air to pass through the workings, must be by causing an increased consumption of fuel; and, from the well-known laws of ventilation, this increase of fuel must be in a proportion somewhat higher than the cubes of the quantities of air going through the workings of the mine before and after the use of such fresh air respectively; because if even the increased quantity of air passing through the workings arose solely from the harder firing of the furnace, the increase should be in the proportion of the cubes of the product of the quantities of air circulating, multiplied by the volume of a given weight of air in the upcast shaft;

which of itself is a ratio higher than the mere cubes of the quantities; and this ratio would, to some degree, be enhanced by the greater per centage of heat lost by cooling, when the increased quantity of air circulated from an increased upcast temperature. But in the case of feeding the furnace with fresh air, the necessary increase of fuel consumed must be in a still higher ratio than that just indicated, inasmuch as there is the fresh air to heat to the same extent as the air that passes through the workings, and the entire quantity of air is to heat to the additional extent required on account of the additional friction that has to be overcome owing to the passage of the fresh air in the shafts, and in the direct passage between them.

It may, therefore, be regarded as certain, that any given quantity of fuel will cause a greater current of air through the workings, when such fuel is consumed by the return air, than when it is either partially or altogether consumed by fresh air not going into the workings.

In the case of Gawber Hall Colliery, as mentioned in Mr. Armstrong's paper, there appears to be some considerable mistake as to the relative quantities of fuel consumed before and after employing the fresh air.

I think there is a much higher degree of verisimilitude about the statement that is given on this head in reference to the quantity consumed after, than to that consumed before the use of fresh air; and if we adopt it as correct, it is easy to perceive that the quantity given as having been consumed before the use of fresh air must be far from being so. After the use of fresh air, we have 25,000 feet of air passing through the workings, and 2500 feet additional passing directly to the furnace and upcast shaft, with a consumption of 10·889 lbs. of coal per minute. Taking, under these circumstances, 1·5 inches of water gauge as the resistance offered by the workings only, and assuming the average downcast temperature at 52 degrees, it would require the upcast temperature to have been 220 degrees to create this pressure alone, apart from the additional temperature required to overcome the friction in the shafts, and in any passages lying on the outbye side of the point where this water gauge was observed. And if we assume the return air to have had a temperature of 60 degrees, this alone would require $220 - 60 = 160$ degrees of heat to be imparted to 25,000 feet of return, and $220 - 52 = 168$ degrees to 2500 feet of fresh air each minute.

Supposing the barometer in the mine to stand at 30·5 inches, and the return air to be saturated with vapour, the fresh air being taken as free

from hygrometrical moisture, we have 1915·15 lbs. of return air mixed with 20·55 lbs. of vapour per minute; and taking the specific heat of dry air at ·238, and that of vapour of water at ·475 to that of water as 1, it would require the furnace to give out 82,397 units of heat per minute to create this temperature in the shaft, in addition to the heat lost by cooling in the shaft. But 10·889 lbs. of coal, taken at 14,000 units of heat per lb., would yield 152,446 units of heat, so that upwards of 54 per cent. of the heat given out by the coals is preserved in the shaft, besides a further per centage due to the pressure overcoming the shaft friction, which is not allowed for in these calculations, there being no data given from which to ascertain its amount; and since we have a prevailing temperature in the upcast shaft, showing that the loss by cooling is considerably less than 46 per cent., we may fairly assume the consumption of coal to have been stated correctly as being seven tons per twenty-four hours, or 10·889 lbs. per minute during the time when 2500 feet of fresh, and 25,000 feet of return air went up the upcast shaft.

If, therefore, we assume the larger quantity of coal to be correctly stated at seven tons per hour, or 10·889 lbs. per minute, and if we decrease this only in the ratio of the cubes of the quantities of air, 25,000 and 13,000 feet per minute, respectively, we only get a consumption of 1·531 lbs. per minute, or of 2204 lbs., or less than a ton per hour, instead of four tons per hour, as stated in the paper; but even this quantity is too high, because it takes no notice of the increased shaft friction due to the increased volume of any given weight of air in the upcast shaft at the higher, as compared with the lower quantity of air; nor of the heat due to the fresh air, nor yet to the probably higher per centage lost by cooling with the higher, compared with that lost with the lower upcast temperature. So that the increased quantity of air obtained by the use of the fresh air current must have been attended with a consumption of at least seven times the quantity of coals, in lieu of only one-and-three-quarter times, as given in the paper; or, on the other hand, it must have resulted in a great measure from changes in the ventilating arrangements, or enlargement of the airways in the workings of the mine; otherwise there must have been some mistake as to the amount of increase obtained by the use of fresh air. Perhaps the consumption was *four tubs*, and not *four tons*, per twenty-four hours, as given in the paper.

By a similar rule, the fuel at Pemberton Colliery should have increased

in the ratio of about one-and-a-half, to increase the air from 57,436 to 65,400 feet per minute, apart from the heat required by the fresh air; but it is only stated to have been increased in the ratio of about 13 to 16.

The increase obtained at Elemore and Eppleton Collieries by closing the furnace doors, as given in Mr. Daglish's paper, show plainly enough that the consumption of coals increased in a ratio higher than the cubes of the quantities of air, even after allowing for the increase of resistance arising from closing the furnace doors.

I am of opinion that it is more economical to obtain any given amount of ventilation from furnace action, by employing a suitable furnace, and allowing the return air from the workings to pass over it, than by the employment of fresh air, either partially or totally, to feed the furnace. At the same time, it must be admitted that there are cases where it is attended with danger to pass the return air over a furnace, and perhaps others where it is so vitiated as to render it unfit to support a sufficiently energetic combustion; and in either of these cases it may become desirable to use more or less fresh air, either alone, or to mix with the return air.

The PRESIDENT said, as to the question of the relative economy of feeding the furnace with fresh air, or allowing the return air to pass over the furnace, he confessed that he was still of opinion, as he had been all along, that the proper way of feeding the furnace was to allow the return air to pass over it. What they wanted was, to produce a certain degree of heat in the shaft. This was done by simply burning in a furnace, a certain quantity of coal; and if they could get out of the fuel all the heat contained in it, by applying the air for that purpose judiciously and properly, he thought they obtained all that they required. He never could think it was the best way of accomplishing this, by taking the air through the bars of the furnace, and so upwards through the fire. It was an excellent mode of producing smoke, but not a good mode of getting all the heat out of the coals. He believed that he had, in evidence before Parliamentary Committees and elsewhere, put on record his opinion that the best mode of working a furnace was to convey the return air over the furnace, with such a velocity as would keep up combustion at a very high temperature; so that, when the coal was thrown on the furnace, the gas of the coal should be expelled by the high temperature, and that this gas should be presented to the action of the furnace in the shape of carburetted hydrogen, which, when ignited, would impinge

upon the coke of the fire. He fancied that the simple combustion of the carburetted hydrogen, passing off into the shaft, would not produce so much heat as if such gas, when ignited, was thrown upon the carbonic oxide, the red-hot coke. The effect of the flame of the carburetted hydrogen upon the carbonic oxide of the coke would produce a much higher temperature, than the flame of each of these gases separately; and he thought if a furnace was worked in this manner judiciously, there would be very little, if any, black smoke produced. He rejected altogether the idea that they should carry the air of such furnaces underneath the bars to produce rapid and perfect combustion. They would effect this more effectively by taking the air over the furnace with a sufficient velocity to keep up intense combustion: and, it would not take anything like the extreme cases put before them by Mr. Armstrong and Mr. Daglish. The increased effect shown by the experiments of Mr. Armstrong and Mr. Daglish arose entirely from the extra quantity of coals consumed. In the experiments of Mr. Daglish, with the doors open over the furnace, they got 46,596 cubic feet of air, with six and a quarter cwts. of coals. They shut the doors over the furnace, and drive all the air under the bars. They then got an increased quantity of air, viz., 47,775 feet; but it was by an increase of nearly double the quantity, viz., with eleven and a half cwts. of coals. Nothing can be more conclusive than these experiments to show that, to throw the air underneath the bars is not the proper way of supplying the furnace with air. Eleven cwts. of coals in the latter case produce very little more air than six cwts. in the other case. All this, however, is apart from the question—What is the best form of furnace? Mr. Daglish proposes a furnace of a different construction from the ordinary furnaces, being fired from the side, and having a very long range of bars, with two or three separate firing places instead of one. In some respects this is better than the ordinary furnace: it is questionable, however, if it comprises the element of economy in the burning of coals, which, in his opinion, should involve a high temperature of the burning matter.

Mr. Atkinson—If you obtain an increased quantity of air, it must be by burning coals in greater quantity, whether this is effected by fresh or return air; but the increase will be greater with fresh, than with return air only.

Mr. Daglish said, there was no such thing as economy of fuel, it did not matter what was the form of the furnace.

The President maintained there must be economy in the consump-

tion of coal, if the whole of the fuel was consumed without the production of smoke, over cases in which they might drive off the whole of the coal in smoke only.

Mr. Daglish said, he was supposing that the smoke was consumed.

Mr. Bell said, the mere consumption of smoke had had more importance attached to it than was due to it. The quantity of solid carbon taken away in smoke was so small, that the mere consumption of it was attended with a small amount of economy. The loss of fuel was generally from want of consuming the carbonic oxide, which was not seen. That would arise from the air passing through the bars instead of a portion of it passing over the furnace. As soon as the air entered into the bars, on which was laid incandescent coal, a portion would be converted into carbonic oxide, which was not only not a supporter of combustion, but the contrary. There was a double decomposition. The quantity of smoke was not only due to the light carburetted hydrogen, but to the precipitation of carbon from the oxides of carbon. He had seen an instance of this. As soon as air enters into an iron blast furnace, even at the rate of 4000 cubic feet per minute, it combines instantly with carbon, leaving not a vestige of free oxygen. An iron master in Belgium proposed the introduction of ground coal at the twyers along with the blast—by which, of course, light carburetted hydrogen would be liberated, and this reacting on the carbonic oxide or carbonic acid, caused the precipitation of solid carbon in such quantities, that, although only a hatful of coal was projected into the furnace, immense volumes of smoke, of the densest and blackest description, appeared at the top of the furnace, although it had passed through the intense heat usually produced in iron smelting. This could only be attributed to the coaly matter of the oxides of carbon, as well as that of the carburetted hydrogen, being precipitated. There was no saving of fuel in this case—rather the reverse. There was one remark he would make as to the temperature of the upcast shafts. The higher you heat the chimney the greater the effect, within certain limits, taking the ordinary law of expansion. If you refer to the elaborate work of Mons. Peclêt, you will find some extraordinary tables with reference to the efficiency of chimneys. You vary the parabola of the curve till it gets to a flattened space. Then, if you heat the chimney to 1500 or 2000 degrees, the effect is not equal to a chimney heated somewhere between 500 and 700 degrees.

Mr. Atkinson—The reason is this:—The air being more expanded, owing to the increased heat, there is an increase of friction due to

its increased velocity, and this friction increases so much more rapidly, than the increase of pressure arising from the increased heat, that it, at a certain point, becomes equal to it; and any additional temperature beyond that at which this equality of the increase of friction to the increase of temperature takes place, only serves to lessen the weight of air passing in a given time. The greatest weight of air circulates in a mine or a chimney in any given time, when the temperature in the upcast or chimney is equal to 375·2° added to twice the temperature of the downcast shaft or outer air respectively, on Fahrenheit's scale; or, if t′=the upcast, and t° the downcast temperature, the maximum draught, in *weight of air*, takes place when $t'=375{\cdot}2°+2t°$. The weight of air circulating in a given time being proportional to $\sqrt{\frac{t'-t°}{(1+{\cdot}00217t')^2}}$; depending, for its actual amount, upon the frictional resistances met with. When the downcast temperature is 32°, the maximum draught takes place when 439·2° is the upcast temperature; and at 495·2° when the downcast temperature is 60°.

Mr. Berkley said, Mr. Armstrong seemed to have the idea of a mine laid out beforehand. If he increased the airway, he would get more air by this plan, though the air might be driven off as gas. He said in one of his mines there was a great deal of stythe and carbonic acid mixed. He could not get the consumption carried to such an extent as he would like, and therefore he drove the air through the bars. Though some of his gases were lost, a greater quantity was consumed than had been previously.

Mr. Atkinson said, in all cases where it was practicable, it was better to consume the necessary quantity of coals by return air, than by fresh air, to obtain the greatest inbye ventilation. There must be friction in the air coming down one and going up the other of the shafts.

Mr. Marley said, he had reason to know that Mr. Armstrong had found it impossible to be present at this discussion.

The President—The question of furnace ventilation will be brought before us at the Birmingham meeting.

Mr. Atkinson suggested that the Birmingham Committee should endeavour to have experiments of the result of the different ventilating machines, to lay before the Birmingham meeting.

Mr. Daglish submitted the following observations:—At the time of the steam jet experiments at Hetton Colliery, in 1852, the Blossom Pit was the upcast for the Eppleton Jane Pit also, and there were about

80,000 cubic feet per minute passing over the large furnace (including above 60,000 from Eppleton). At this time the area over the bars was very large, viz., eight feet high.

Area above = 32 feet.

Area below = 22 feet.

And taking the velocity below and through the bars to be one-sixth of that above, which I have found, by experiment, to be the case, the required area for a uniform velocity will be $\left(\frac{18}{6}\right) = 3$ ft., which, added to that above makes in all sixty-seven feet; and taking the quantity at say 80,000 cubic feet per minute, the velocity is about 1195 feet per minute, or twenty feet per second.

When the Caroline Pit was sunk, the Eppleton air was taken off this furnace, and the quantity at present passing over it is not one-third of what it was, say 27,000 feet. Now, in order to keep the temperature of the upcast and the quantity of coals consumed the same, this being required for the ventilation of the Hetton Pits, the velocity of the air passing the furnace must be the same, that is, equal increments of oxygen must be brought into contact with the burning fuel in a given time. It would be necessary, therefore, to reduce the area above the bars to nineteen feet (the area below being still three feet for a uniform velocity); and I find that this has actually been done. I observe that, five feet above the bars, an iron bearer has been put in, and built with bricks, and this not having given sufficient draft, another, two feet lower, has been put in, making the area over the bars about twenty-five feet; showing that, in practice, it had been found necessary to contract the air over the fire very considerably.

Mr. Bell states, that it was a well-ascertained fact that, one foot above the twyers, where the air enters the blast furnace, it was *all* converted into carbonic acid (CO_2), combustion being perfect, and the heat most intense at this point, but that in ascending it is robbed again of a portion of its oxygen by the burning fuel (C), and ultimately passes off at the top, principally as carbonic oxide (CO) and nitrogen (N).

The action may be expressed thus—One foot above the twyers $C + 2 (4 N + O) = CO_2 + 8 N$; and higher up, $CO_2 + 8 N + C = 2 CO + 8 N$.

In an article in last week's *Mining Journal* the same views are put forth, and it is stated that "perfect combustion is attained by passing a strong blast through a *thin* fire."

In Juke's patent furnace, in operation at New Elvet, the consumption of smoke is perfect, the fire is very thin, and no air passes over the fire at all.

The greatest heat that can be obtained from a given quantity of fuel, is by converting it all into carbonic acid (CO_2) and water (HO), thus—

$$\overline{C + CH_2} + 6O = 2\,CO_2 + 2\,HO$$

where the fuel is represented as a combination of coke (C) and gas (CH_2), and the residue, after combustion, as carbonic acid (CO_2) and water (HO).

But if the gas be volatilized and passed over the carbonic acid formed by the perfect combustion of incandescent coke, in all probability large quantities of smoke would be formed, thus—

$$CH_2 + CO_2 = 2\,HO + 2\,C$$

for the affinity between the hydrogen (H) and oxygen (O) being stronger than between either the hydrogen and the carbon (C) or the carbon and oxygen, the hydrogen in the carburetted hydrogen would leave the carbon to combine with the oxygen of the carbonic acid, and the carbon (or smoke) both of the carburetted hydrogen and the carbonic acid would be deposited.

The discussion was then adjourned.

DISCUSSION ON THE HETTON ACCIDENT.

Mr. Reid said he understood Mr. Maynard, the Coroner, had published a book of the accident.

The President said, he had a copy of it in the room. It was a copy of the whole of the evidence, and extracts from some newspapers on the subject; also the evidence taken at the Felling inquest; and likewise an epitome of the discussion at Manchester.

Mr. Daglish read the following letters received from Mr. Longridge, Secretary of the Steam-Boiler Insurance Company; also a letter from Mr. Wood, who had charge of Tursdale Colliery, and others, all relating to accidents in flues.

[COPY.]

"*Steam Boiler Assurance Company,*
Offices, No. 1, *New Brown Street, Market Street,*
Manchester, Jan. 28, 1861.

"Dear Sir,—I have been prevented sooner replying to your letter of the 23rd inst., relative to the late explosion at Hetton, of which I had already received some particulars from Mr. Reid, of Pelton.

"Explosion of gas in the flues of boilers has occurred occasionally in

boilers under my inspection. One of these boilers was multitubular, with a large internal furnace; but as boilers of this construction always leak and corrode in the underside. Owing to the unequal expansion, when there is no heat underneath, a flue had been made below this boiler, so that the products of combustion would pass along one side towards the front, and then back by the other side to the chimney. Owing, however, to some contraction where the flue descended, the draught was injured, and to remedy this, a few bricks were pulled out of the wall that had been built to stop the direct communication with the chimney. This opening would be about nine inches square, and had the desired effect; but every now and then, when the fireman opened the fire door to throw in fresh coal, an explosion took place, and on one occasion he was so severely burnt that the brick wall was entirely pulled down to allow direct communication with the chimney, and there has been no trouble since.

"It appears that the flues below the boiler became filled with carburetted hydrogen, and in opening the fire door the air entered, and on becoming mixed with the gas, an explosion followed.

"In another case, the boiler was of similar construction, with a smoke-box at the back end, in which was a small door. The flue passed down and along the underside of the boiler to the front, where was a damper working in a spindle, like a common wing-throttle valve. The owner of the mill had gone with another gentleman to the smoke-box end, and opened the small door to let his friend feel the temperature of the gases passing through the tubes. The fireman, meanwhile, threw on some fresh fuel, and shutting the fire door, went to the adjoining boiler to do the same. He, however, observed that the smoke was coming out from the fire he had just left, owing to the damper having swung to. He therefore opened it again, one of the gentlemen at the same time having his hand in the smoke-box to feel the heat, when immediately there was an explosion of gas, the flame rushing out at the smoke-box door, and scorching both the gentlemen rather severely. Here, also, you will see the flues had become charged with the gas, and on opening the damper the gas ignited.

"Other similar explosions occurred in a Cornish or two-flued boiler with fires in the flues; but here sawdust was used with the coal, and it appears that the gas mixed with the sawdust, which almost filled the flues, and thus excluded the air; but on opening the fire door and disturbing the sawdust, so as to allow the air to mix with the gas, a sheet of flame would rush out.

"These are all the instances I recollect at present; but there have been others. From the account I read in the papers of the Hetton explosion, I can readily believe that the cause was the same as in the instances above given.

"I am, dear Sir,

"Yours truly,

"John Daglish, Esq. "ROBT. W. LONGRIDGE."

[COPY.]

"*Steam Boiler Assurance Company,*
Offices, No. 1, *New Brown Street, Market Street,*
Manchester, Feb. 2, 1861.

"DEAR SIR,—I had intended being present at the next meeting of the Institute of Mining Engineers, to hear the discussion on the Hetton accident, but I fear my other engagements will prevent my doing so. Since I wrote you on the 28th ult., I have seen a plan showing the position of the boilers, shafts, &c., of the Hetton Colliery, and can perfectly understand how the explosion must have occurred.

"The arch in the flue where it crossed the roadway would facilitate the accumulation of gas between this point and the boiler, and as there appears to have been an opening where air could enter to combine with this gas, the presence of the explosive materials is fully accounted for, as a large amount of carburetted hydrogen was certain to be produced by the damping of the fire, and it only required its equivalent of oxygen (to be obtained from the air) to render it explosive on coming in contact with any fire or flame. After an hour or two, I have no doubt the front part of the fire, or that nearest the damper, would have burnt up so as to be in a condition to communicate a flame to these gases, and then the explosion would take place.

"The remedy is simple, and on this account I now write to you. If, in damping the fires, instead of filling up the doorway with coal so as to exclude the air, according to the usual practice, air were freely admitted *above the fuel,* any gas which might be evolved would either be consumed or be so diluted with air as to render explosion impossible.

"Yours truly,

"John Daglish, Esq. "ROBT. W. LONGRIDGE."

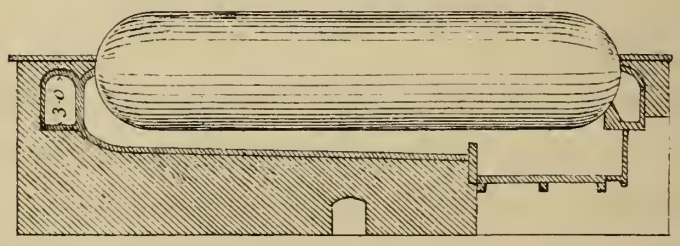
[COPY.]

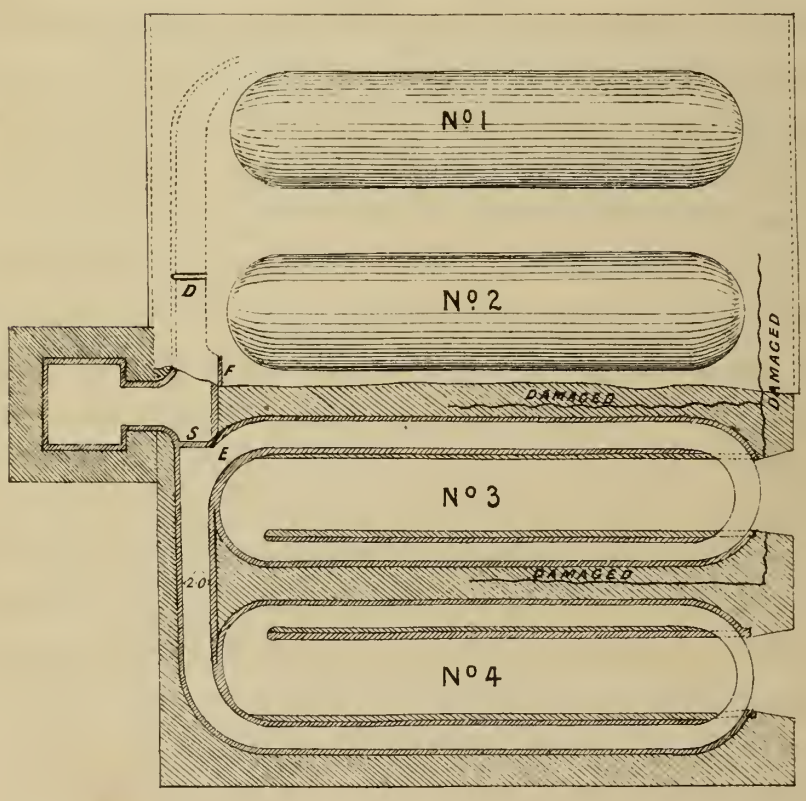
"*Tursdale Colliery.*

"On Monday, the 4th of January, 1858, a slight explosion in the

PLAN OF BOILERS
AT
TURSDALE COLLIERY

SCALE 1/16 IN. PER FOOT.





Proceedings No. of E. I. of M.E. 1860 I.

Lithographed by A. Lee, Newcastle

boiler flues at Tursdale Colliery took place, the facts of which I submit in connection with this inquiry.

"There were four boilers, with wheel flues arranged into the stack, as shown on the accompanying drawing. Only No. 1 boiler was in use, the other three not having either fire doors or fire bars fixed. At a point of the main flue, as shown at S, also at F, a temporary stopping of 4½in. brickwork, and, as it appears, not airtight, was fixed, to make the draught to the stack steady from No. 1 boiler fire. A damper at D in the main flue regulated No. 1 fire. This was working in a metal frame, and formed a tight joint at the sides.

"The fire of No. 1 boiler had been damped, as usual, on the Saturday night previous, the damper being lowered to within about 1½ inch of the bottom of the frame. On the Monday morning, steam was got up at one o'clock, and it was not till five o'clock, all having to this time gone forward as usual, that, as the fireman opened the doors to throw on coals, the explosion occurred. A sheet of flame flashed in his face, and a loud report followed. The buttresses between 2 and 3 boiler and 3 and 4 were injured, and partly blown out, and it was found that the top of the flue at E was completely lifted off—the flues between 2 and 3 and 3 and 4 being also lifted in the parts shown by the blue line in drawing.

"When the flues were uncovered, the stopping S was found to have been thrown down towards No. 2 boiler: the stopping F was standing. The explosion had taken greatest effect at E, and along this flue towards the fire door end, producing the results explained.

"The flame from No. 1 fire seems to have communicated itself through the temporary stoppings to an accumulation of gas in Nos. 2 and 3 flues. This accumulation may, I think, be accounted for by some particular direction of the wind preventing the regular escape, by the stack, of the gas disengaged from No. 1 fire when damped, and thus allowing it to work through the stoppings. It is difficult, however, to understand why the draught towards the stack, which would necessarily set in from Nos. 2 and 3 flues, when the No. 1 fire was set away, did not carry this gas back through the stoppings, and cause the explosion at 1 A.M., when the fire was first raised.

"WILLIAM COCHRANE."

The PRESIDENT said, with one part of the subject every gentleman present was conversant—that was, the ventilation of the colliery. It was important to know whether they thought that, by any possibility,

the explosion could have occurred by gas coming from the workings. On this point he should like very much to have the opinion of any of his friends around him who had heard or read the evidence. Mr. Daglish was present, and could give any further explanations. It had been stated in some of the papers that it might have come from a particular quarter of the pit, viz., from the north way in Charlton's Pit—the East Minor Pit.

Mr. Atkinson—That was simply ridiculous. There was no means of the gas getting ignited in the return, had gas been there. There was no symptom of any blast coming that way. What there was, looked as if it had gone inwards instead of outwards.

Mr. Reid—Comparing this with the Felling accident, there was much greater improbability of any gas coming from the Hetton workings. He was aware that there were goaves in all directions round the boiler at Felling, having been present at that inquiry. The Hetton case was a much clearer one than the Felling; but to say there could be no communication would be tantamount to saying that there were no goaves in the pit.

The President had read the evidence given at the Felling inquest. The air went direct from the pit to the boilers. There was no communication between the boiler and flues, and the return air.

Mr. Reid—But there was an apparent likelihood, in any fall that took place in the workings, that the air might back to the furnace.

The President—Did the return air enter at all into the flues? His impression was, it went in a separate course to the upcast shaft.

Mr. Reid—There was gas in the Hetton pit, though it might not have anything to do with the accident.

Mr. Daglish would not admit that there was gas in the pit.

Mr. Reid said, he knew that was the feeling of those who had heard the evidence. However, as compared with Felling, there was no possibility of the explosion being from gas in the workings.

The President would like the question to be considered on its own merits. If there had been any communication with the gas of the workings at all, and that such gas had come off from the goaves, it would have come along the return. It would not go back and face the ingoing air: it would have come out at the returns at the furnaces. Now, you have these facts at both returns. At the one return, viz., the east furnace, you find the blast coming from the furnace to the furnaceman—directly in the opposite direction to that which it would have come

if it had occurred from gas in the return air. The gas could not likewise have come in that direction, unless it had come past the two west furnaces, and in that case it would have exploded at these furnaces. But you have the fact of the men about these furnaces not being burnt at all. The men were clearly suffocated by the after-damp, and not burnt. Then, as to the east furnace, the furnaceman said, when he got up to put coal on the furnace, he met the blast coming from the furnace: and he was driven away in the opposite direction and saw no flame. This was a proof that no air from the furnace in a state of inflammation had passed him. It would have burnt him; but this man was not burnt. It was clear, therefore, that there was no explosion of gas in the return air passing to the furnaces—the only direction in which gas from the pit or goaves could by possibility have come.

Mr. Daglish—A hundred yards from the north side of the flue the greatest apparent result of force was exhibited. The end of the shaft of the engine was broken, and the whole of the trams were moved six inches inbye. That was the focus of the greatest violence.

The President—Can you show this locality on the plan?

Mr. Daglish—It was called the Victoria engine.

The President—That is in the main north way.

Mr. Daglish—About fifty yards north of the crossing of the flues.

Mr. Dunn said, he had not the least doubt or difficulty, after hearing the evidence and seeing the plans, in coming to the conclusion that the accident could not have arisen from the state of the mine. It was certainly an unexampled state of the chimney.

The President—Then, supposing it to have occurred in the flue, how did it occur? Mr. Bell had stated in his evidence, very fully, how he supposed it had occurred. What was the opinion of the gentlemen present?

Mr. Berkley inquired if there had been a discovery of any symptoms of burning in any other part. As far as he had learned, there was not a single man burnt in the pit.

Mr. Daglish—One man was said to have been burnt; but he had examined his dress with a microscope, and could find no traces of burning.

Mr. Bell said, Mr. Daglish got upon his high horse when any one launched an observation against the possibility of the colliery containing gas. Still, he believed no mining engineer present would be deterred from expressing his opinion: their object was to get at the truth of the matter.

He went down the pit unaccompanied by Mr. Wood, who invited him to make the inspection. Though he was not a colliery engineer, he was sufficiently acquainted with analogous cases to enable him to form an opinion. There could be no doubt in the mind of any one who carefully examined the subject, that in the flue, and there alone, the explosion occurred. He did not go far into the workings, but he went far enough to satisfy himself that there had been no explosion in a contrary direction from the flue. Why give themselves the trouble to ask whether the gas came from the goaf or not. The gas when exploded was in the flue. He thought it was proved in evidence that it was impossible for it to have come from the interior workings, because the furnace of the engine was exclusively fed from the downcast. The issue from the furnace was in equally close proximity to the upcast shaft. Then, if they started from the admission that the explosion took place in the flue, they would simply have to inquire whether the gas so collected was sufficient to produce all the phenomena so as to avoid such accidents in future. He remembered, immediately after the accident, meeting some gentlemen in the railway train, and the matter was discussed. He utterly scouted the idea of any quantity of gas lodged in such a flue being sufficient to cause the explosion. But we might come to a hasty conclusion. A great deal of misapprehension had arisen from the comparison of an explosion from gas under circumstances totally different from those which are exhibited here. Whenever you set fire to gas, there is the production of heat by the union of this gas with oxygen; but, at the same time, there is this antagonistic fact, that by the expansion of the gases, which are the resultants of this combustion, you have a cooling effect. For example—We all know how easy it is to hold the hand in high-pressure steam. Also, when you condense carbonic acid to a certain point, and let it out, the expansion is so rapid and the cooling influence so great, that a portion of the carbonic acid is thrown down in a solid state. Now carbonic acid does not freeze till it has reached 125 degrees, and yet this depression is thus produced by the exit of gas at an ordinary temperature, freezing itself by its own expansion. This is the effect in all flame:—heating, the effect of combustion; and cooling, the effect of expansion. The balance between the two is the result of the heating power. If you alter the circumstances—if you put a stop to the expansion—the results are totally different from ordinary combustion. In one of the latest works he had examined, this was brought out. This was the work of Gay Lussac, who died some years ago. Burning light carburetted hydrogen, the temperature of the combustion was represented as 18,329 degrees.

Mr. Atkinson—This is in pure oxygen.

Mr. Bell—Yes. This is burning under pressure; but burning freely it is 14,331—a difference of 4198, or 23 per cent. loss by burning the gas where expansion is permitted. At the inquest he had mentioned incidentally a tube which exploded. Since then he had got accurately the dimensions of this tube. From the investigations of late years, particularly those of Mr. Wm. Fairbairn, we get a tolerable notion of what the power is that can rend asunder boilers of all dimensions. The tube in question was three feet in diameter, and 200 yards long. It was filled with carbonic oxide. According to the formula given by Mr. Fairbairn, it would require 472 lbs. to the square inch to rend it asunder. But at Hetton we have light carburetted hydrogen, which producing a greater temperature, gives a greater expansion. One end was open; so it was in this flue. If you took one-half of the expansive power, it would act as a magazine of powder. This is pretty much the condition of things which prevailed at Hetton pit. In the evidence which he gave at the inquest he kept a long way within the mark. He had seen since, from the experiments of Bunsen, that the expansion due to gas burnt in this way was very much higher than he had anticipated. He wrote to Dr. Michael Faraday to ask his opinion, and he replied that, "not having examined the scene of action, he would not commit himself;" but he did say that, "assuming the premises to be correct, he saw no difficulty of conceiving that the effects described were due to this cause assigned by me." The Manchester gentlemen saw no reason to find fault with our conclusions; and the more he looked into it the more he was convinced that the flue, being filled with gas, probably from a fracture in the damper, an explosion would take place, which would be quite equal to all the effects produced.

The President—You observe that necessarily the explosion was very much confined. It seemed to have been confined to the four main roads proceeding from the two shafts. These were the leading waggonways from the pit. It was clearly shown that the explosion terminated at a certain distance along these lines of road. You have the evidence of a man 800 yards from the shaft: it knocked him down. You have the evidence of another man 200 or 300 yards farther off: he felt it, but it did not knock him down. Then you have the evidence of a man farther in still. Here the effect was so trifling that, though he heard it, he hardly knew what it was. In all the directions from the locality of the explosion, looking at the effects, it seemed to terminate at the distance of about 1400 yards. It seemed to have been a force terminated by the

resistance to its velocity by the friction of the passages, and brought to a standstill at a certain point. The effects extended over the space of about 1400 yards in each direction: beyond that the explosion was not felt. That appeared to have been the limits of the explosion. It did not appear to have been a force continued for a length of time, and spread over a continuous extent of space. It was a smart explosion, emanating from a specific point, which drove the current of air in the mine in all directions with great force from the locality of the explosion as a centre, and gradually diminished to a certain point, which would be the effect of a sharp sudden explosion, and would not require a large quantity of gas to produce such an effect. If it had been an explosion of a pit filled with gas, the explosion would have gone through the whole of the pit, filling the returns along which the gas would be passing, and the effects would have been seen in the workings and in those returns. But the workings and return passages were never touched; there had been no explosion in them. It was only in the main ways, where the air direct from the downcast was passing, where the explosion and its effects appear. What surprised him was, that the men were killed at such great distances from the centre of the explosion. It might be they were killed by the after-damp; but they found men struck down and killed instantaneously where they were standing. It must have been sudden, as some of the men could not have moved, even for a yard or two, before they were struck down dead. At Lundhill the same thing happened. One man was struck down dead before his arm could be relaxed from the blow he was giving the coal with his pick. He was found dead, sitting in the attitude of striking the pick into the coal. This may have been done by the sudden concussion of the air. His own notion was, that generally the men were killed by the concussion, and not by the after-damp, except in some cases. He would not here repeat the observations of the gentlemen at the meeting of the Geological Society of Manchester, where the subject was discussed, as it had been published in the "Transactions" of that Society, and also in Mr. Maynard's publication.

Mr. Daglish, in reference to an observation made by Mr. Bell, said he hoped no private or friendly feeling towards himself would prevent any gentleman from pointing out any difference of opinion he might hold respecting this accident. No one was affected by the question more than himself, for he was down the pit constantly, and therefore exposed to any danger that might exist.

Mr. Hall said, there was one thing he wished to say. Mr. Bell did

not go into the workings to see whether the goaves were highly charged with gas, or slightly charged, or not at all.

The PRESIDENT said, the evidence at the inquest of the men having charge of the goaves, was, that they travelled the goaves during the day on which the explosion occurred, and did not see any gas at all. There was one thing mentioned by Mr. Bell in reference to what might be supposed to have ignited the gas, viz., the damper, that there were symptoms of its having been cracked, and the possibility that it might have given way immediately before the explosion, and so thrown into the flues a large quantity of air rapidly, and thus produce an explosion. He had been making inquiries since, and although it did not seem certain that such was the fact, yet it was the opinion of some of the engineers who examined the damper, that it did show symptoms of a crack. He had sent for Mr. Hedley, who was the person Mr. Forster named, and he was of that opinion.

Mr. DAGLISH—We did notice it, but could not tell whether it had been recent or not—whether it took place after the accident or before.

Mr. BELL said, he did not make the observation from having heard that the damper was cracked; but from the fact that this flue had existed thirty-four years without an explosion, he was led to ask whether there was something in the thirty-fourth year which had not occurred previously. It then occurred to him that the damper might have cracked. After this, Mr. Forster came and told him that there were some symptoms of an old crack. Mr. Berkley had put a question as to the stables being set on fire. There was no difficulty in assigning satisfactory reasons for this. Assuming that the gases did not lose their heat immediately, which they had no reason to do, this gas itself might set fire to the stables; but whether or not, they knew that a common gun would send a piece of burning wadding a hundred yards or more. They might, therefore, readily imagine that matter originally incandescent, taken along with this extraordinary quantity of heated gas, would be sufficient to set hay or straw on fire. They might remember that, in the great explosion at Gateshead, parts in Newcastle took fire in nearly 100 places at once, from the embers being projected across the river, 200 yards wide, and we may easily assume the same thing happened here—

The PRESIDENT—The stables were not a great distance from the explosion—about 300 yards.

Mr. BELL—In the case of boiler fires, we have seen that there is an ignition of inflammable air under boilers, and that would be extended

into the flues. The difficulty in one case is, that these flues seem to have lasted upwards of thirty years, and no explosion has taken place until a particular occasion.

Mr. Atkinson—There was one at Spennymoor a few years ago, when four people were killed.

The President—This case would, no doubt, excite the attention of all professional men, and they would, he thought, ventilate the flues more extensively than they had done hitherto; but it had staggered him as to whether it was advisable to place the boilers underground or at bank. Unless the pits were very deep, he thought the boilers should be placed at bank, and the steam conveyed underground. He had made some experiments of the difference between boilers placed at bank and close to the engine, and boilers placed underground, the steam being conveyed down the pit, and there was nothing like that diminution of effect which he had at first anticipated. He had made experiments at one pit at Heworth, 130 fathoms deep, and he had found that the same effect was produced by the same fuel in engines placed underground, the steam being conveyed down the pit from boilers placed at bank, as with engines and boilers both at bank and with the boilers close to the engine. There was, therefore, practically no waste of steam, and no diminution of pressure. He did not think, therefore, there was much gained by having the boilers underground; and if they could prevent such like accidents by having the boilers at bank, it was worth looking at as a practical question, especially as the boiler fires of the underground engines abstracted a large portion of the air required for ventilation.

Mr. Daglish—When you come to multiply the boilers, the abstraction of a quantity is felt. 40,000 feet per minute, required for four boilers and flues, leaves very little for the ventilation of the mine.

Mr. Atkinson—That is an additional reason for placing the boilers at bank.

Mr. Daglish—The cost of the various flues and boilers underground was also a serious question.

Mr. Bell—There must be a great loss of heat in conveying the steam so great a length as your shaft. The question was not only as to the quantity of water, but the quantity of coal consumed. It was important that they should not rob the heated air of any of its effect, which they did in heating the boiler.

Mr. Atkinson said, it was partially returned again. The watery vapour lightens the upcast column.

Mr. Bell—When it condenses it gives off the latent heat again.

Mr. Atkinson—The air will generally hold it all in the form of invisible vapour.

The President—The reason why there was not so much condensation in the pipes conveying the steam down the shaft was, that the upcast shaft was generally used, and was pretty warm. More than this—the boiler being close to the engine, they found a quantity of water thrown off into the cylinder; whereas the pipes conveying the steam underground acts neither more nor less than as a large reservoir, and prevented much of the mixture of the water with the steam, which was the case when the cylinder was placed near the boiler.

Mr. Hall said there was a remedy by having the steam engine at the top of the pit, with a boiler or receiver for it, and to force high-pressed air into the mine to work the engines underground, and to a certain extent this would increase the ventilating air rather than diminish it.

The President—There was a case of this description at a colliery near Glasgow, but the result was doubtful.

Mr. Atkinson—Its effects upon the ventilation would not be felt.

The discussion here closed and the meeting adjourned.

NORTH OF ENGLAND INSTITUTE

OF

MINING ENGINEERS.

GENERAL MEETING, THURSDAY, MAY 2, 1861, IN THE ROOMS OF THE INSTITUTE, WESTGATE STREET, NEWCASTLE-UPON-TYNE.

Mr. Hurst in the Chair.

Notice was given that the meeting in June would be special for the election of officers.

Mr. Berkley read a paper, by Mr. J. J. Atkinson, on "The Strength of Tubbing in Shafts, and the Pressures or Forces it has to resist."

Mr. Johnson was not present, and there was no discussion.

The Chairman remarked, that the paper was not merely theoretical, but practical, and it settled the point as to the utility of cement for tubbing.

The meeting then adjourned.

ON THE

STRENGTH OF TUBBING IN SHAFTS,

AND THE

PRESSURES OR FORCES IT HAS TO RESIST.

By JOHN J. ATKINSON.

In the discussion, which took place at the last general meeting of the members of this institution, relative to the proposed employment of Portland cement in lieu of cast iron, for tubbing back the water in the shafts of mines, I made a few remarks as to the thickness of such cement that would be destroyed by the crushing force arising from the pressure of 100 fathoms of water, in a shaft fourteen feet in diameter; and also as to the minimum thickness of cement that it would be necessary to employ for safety, under the same conditions as to pressure and size of shaft.

Since that time I have received a letter from Mr. I. C. Johnson, from which I gather that that gentleman believes me to have made some mistake in the hasty calculation upon which I founded my remarks, calculated to have an unfairly damaging effect upon the proposed substitution of Portland cement in lieu of cast iron, for the purpose in question; and desiring me first to satisfy myself that I had made such a mistake, and then to convince the gentlemen who heard my remarks, of the true state of the case.

I wrote to Mr. Johnson, in reply, that I believed that what I had stated was correct, but that I should be happy to render any explanation on the subject at the present meeting.

Under these circumstances, I beg leave to lay before the members, the following remarks on the strength of tubbing in shafts; and the forces it has to resist; in which I have taken the particular conditions, as to the depth of water and size of shaft, upon which were based my remarks at

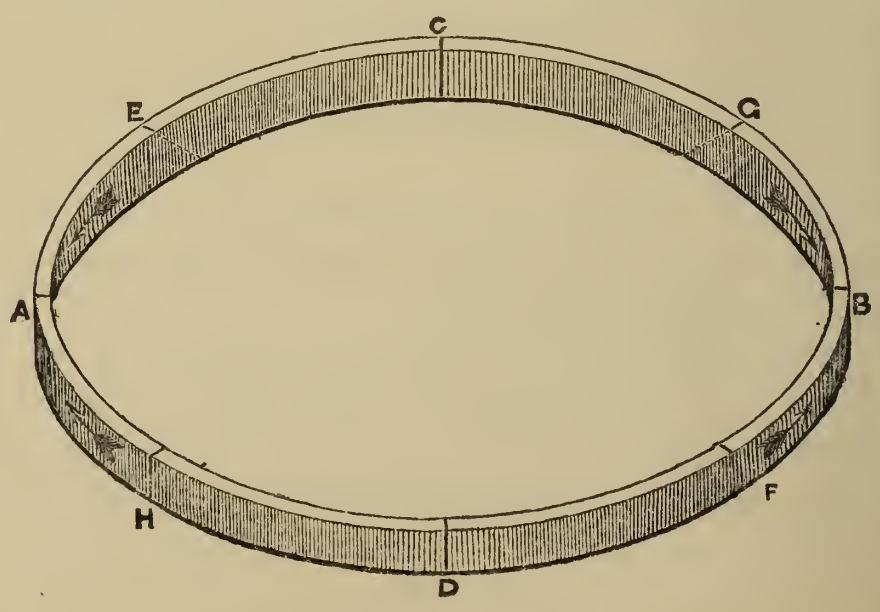
the last meeting; as examples of the application of some of the rules now given.

The remarks which I made at the last meeting, in reference to this subject, were to the effect, that if Portland cement would only bear a pressure of about twenty-one cwts., or 2352 lbs., per square inch, before being destroyed by the crushing force, blocks of this material, eleven inches thick on the bed, would be destroyed by the crushing force due to 100 fathoms of water pressure, if employed as tubbing in a shaft fourteen feet in diameter; and that, in order to ensure safety, it would be necessary that the material should be not less than three feet thick on the bed, under the same conditions as to water pressure and size of shaft.

Although these statements are considered by Mr. Johnson as being calculated to have an unfairly damaging effect upon the proposed introduction of Portland cement, as a substitute for cast iron to form shaft tubbing, I think I shall be able to show that they are within the truth; and that, for an ordinary degree of safety, it would be necessary to employ a considerably greater thickness than three feet of the material, under the conditions stated, as to pressure and size of shaft.

Before giving formula for calculating the *greatest* crushing force to which the material forming the tubbing of shafts is subjected, owing to the pressure of water behind it, I will investigate formula relative to the *average* crushing force to which it is exposed; because their investigation are much more easily comprehended, while, at the same time, they give results which are perfectly reliable for practical purposes, in all cases where the thickness of the material is small in comparison with the inside diameter of the shaft; and this is always the case where cast iron is the material employed.

Let the accompanying figure represent a horizontal ring of tubbing in a vertical shaft, with a column of water pressing upon its outer surface.



It is manifest that the whole of the horizontal pressure acting upon the outside of the half ring A B D, will be counteracted by a similar horizontal pressure in the opposite direction, acting upon the other half ring A C D; but the sectional area of the solid substance of the ring at A and B will have the whole pressure (resolved into a direction at right angles to the diameter A B) due to the half ring to sustain—such pressure tending to crush the material of the ring at A and B, in a circumferential direction, as shown by the darts.

If we view the pressure of the water as acting in a horizontal direction, from the circumference towards the centre (in a radial direction), and resolve the whole of the radial forces into a direction at right angles to any diameter, we shall find their sum to be the same for a half ring as if they acted directly upon a plain surface equal in length to the diameter itself, and of the same depth as the ring.

From what has been stated, it follows that the material of the ring at each of the points A and B, and, indeed, in every part of the circumference, has to sustain a crushing force equal to the pressure upon a plane surface, having the outer radius for its length, and the same depth as the ring itself—such crushing force operating in a circumferential direction, all round the ring. If we let

t = the thickness of the material, in inches;
d = inside diameter of shaft, in inches;
p = water pressure in lbs., per square inch;

then the pressure on each half of the ring of tubbing, resolved into a direction at right angles to the diameter of the ring, supposing the ring to be one inch deep, is

$$p\,(d + 2\,t)$$

But the area of the material, or substance of the ring, which has to sustain the crushing pressure, is only 2 t; and on the *average*, therefore, each square inch has to sustain a pressure of $\frac{p\,(d + 2\,t)}{2\,t}$, and calling this crushing force $\angle$ we have the equation

$$\angle = p\left(\frac{d}{2\,t} + 1\right) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

But if we substitute δ as the inside diameter of the shaft *in feet*, in place of d, its diameter *in inches*, we get

$$\angle = p\left(\frac{6\delta}{t} + 1\right) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

If into this formula we introduce F for the depth of water, in fathoms, that has to be sustained by this tubbing; since each fathom in depth of

water produces a pressure of 2·6 lbs. per square inch, we obtain $p = 2{\cdot}6\ F$; and this, substituted in (2), gives the following equations:—

$$\angle = 2{\cdot}6\ F\left(\frac{6\delta}{t} + 1\right) \quad \ldots\ldots(3)$$

$$t = \frac{6\delta}{\frac{\angle}{2{\cdot}6\ F} - 1} \quad \ldots\ldots(4)$$

$$F = \frac{\angle}{2{\cdot}6\left(\frac{6\delta}{t} + 1\right)} \quad \ldots\ldots(5)$$

$$\delta = \frac{t\left(\frac{\angle}{2{\cdot}6\ F} - 1\right)}{6} \quad \ldots\ldots(6)$$

Where the thickness of the material of the tubbing is small in comparison with the diameter of the shaft, any of the equations (3) (4) (5) or (6) may be employed, without material error, in making calculations as to the strength of the tubbing; and by assuming the value of $\angle$ as the crushing force in lbs. per square inch, the equations will give the conditions under which crushing will ensue; or, if we assume the value of $\angle$ at a safe working load per square inch, the results will come out, from the use of the equations, as the conditions for safe working.

The resistances of materials to crushing by a direct thrust, *in lbs. avoirdupois per square inch*, are as follow:—

	Resistance to Crushing.
Brick—Weak red	550 to 800
Strong red	1100
Fire	1700
Granite	5500 to 11,000
Limestone—Marble	5500
Granular	4000 to 4500
Sandstone—Strong	5500
Ordinary	3300 to 4400
Weak	2200
Portland cement, per Mr. I. C. Johnson	2352
Metals—Brass (cast)	10,300
Iron (cast), various qualities	50,499 to 130,860
,, average	91,059
,, wrought, about	36,000 to 40,000
Timber—Dry, crushed along the grain: green timber being much weaker in resistance to crushing.	
Ash	9000
Beech	9360
Birch	6400
Elm	10,300
Fir—Red pine	5375 to 6200
American yellow pine	5400
Larch	5570
Oak—British	10,000
Dantzic	7700
American red	6000

Let it be required to find what thickness of cast iron tubbing would be destroyed by the circumferential crushing force, in a shaft fourteen feet diameter, and at a depth of 100 fathoms below the surface of the water, assuming the cast iron to be crushed under a force of 90,000 lbs. per square inch. By (4) we have

$$t = \frac{6 \times 14}{\frac{90{,}000}{2{\cdot}6 \times 100} - 1} = {\cdot}243 \text{ inch, the thickness.}$$

But if we take the safe working load upon the metal as 1-6th of the force required to crush average cast iron, or at 15,000 lbs. per square inch, and allow 1-8th of an inch for wear, tear, and corrosion, the safe working thickness becomes—

$$t = \frac{6 \times 14}{\frac{15{,}000}{2{\cdot}60 \times 100} - 1} + \tfrac{1}{8} = 1{\cdot}607 \text{ inches.}$$

In practice, I should not consider it safe to load the cast iron of tubbing at more than 15,000 lbs. per square inch of sectional area, or about 1-6th of the force required to destroy ordinary cast iron by crushing; and I think a constant thickness should be added to that which is required to reduce the working load to this amount, in order to allow for loss of thickness and strength, by wear and tear and chemical action; such extra thickness depending for its amount upon whether it is intended for a downcast or an upcast shaft, and whether or not smoke and gases from furnaces and boiler fires are intended to pass up it; as well as upon the quality of the water behind the tubbing.

The rules just given are based upon the assumption that the circumferential crushing force acting upon tubbing is *equal at all parts of its thickness*, which is *nearly* true where the thickness of the tubbing is small in comparison with the diameter of the shaft; but departs more and more from the truth as we increase the ratio of the thickness of the tubbing to the diameter of the shaft; and they will be considerably in error in their application to such a material as Portland cement, at the depth of 100 fathoms of water, because the thickness of that material must necessarily be considerable, in proportion to the shaft diameter, under such conditions. Applying (4), however, to a fourteen-feet shaft, under 100 fathoms of water pressure, and taking the force required to crush the Portland cement at 2,352 lbs. per square inch, we have

$$t = \frac{6 \times 14}{\frac{2352}{2{\cdot}6 \times 100} - 1} = 10{\cdot}44 \text{ inches as the thickness of cement that}$$

would be crushed under such conditions.

Applying the same rule, and taking the working load at as much as one-third of the load that would destroy it by crushing, we have

$$t = \frac{6 \times 14}{\frac{784}{2{\cdot}6 \times 100} - 1} = 53{\cdot}7$$ inches or about four feet, five and three quarter inches, as the thickness of such cement required to reduce the *average* working pressure per square inch, to one-third of the crushing force.

It is, however, shown in "Rankine's Applied Mechanics," that when a thick hollow cylinder is exposed to pressure from without, there is a circumferential thrust round it, whose greatest intensity takes place at the inner surface of the cylinder; so that the ultimate strength of the cylinder does not depend upon the *mean* or *average* circumferential thrust, but upon its *greatest* amount, as exerted at the inner surface of the cylinder; and that, *supposing the material just to give way by direct crushing*, the ratio of the internal to the external radius of the cylinder is given by the equation

$$\frac{r}{R} = \sqrt{1 - \frac{2\,p}{\angle}} \quad \text{.......................................(7)}$$

Where r = inside radius of the cylinder.
R = outside ditto.
p = outside pressure on each unit of surface.
$\angle$ = the greatest thrust or crushing force on the unit of area of material, as prevailing at the inner surface of the cylinder.

Taking a ring of tubbing, one inch deep, as the cylinder, and substituting the symbols previously employed, this formula conducts to the following—

$$\frac{d}{d \times 2\,t} = \sqrt{1 - \frac{2 \times 2{\cdot}6\,F}{\angle}} \quad \text{.................................(8)}$$

and hence come the following rules for tubbing composed of Portland cement, or any other material requiring a considerable thickness in proportion to the diameter of the shaft, to render its employment safe—

$$\angle = \frac{5{\cdot}2\,F}{1 - \left(\frac{1}{1 + \frac{t}{6\delta}}\right)^2} \quad \text{.....................................(9)}$$

$$t = 6\delta \left(\frac{1}{\sqrt{1 - \frac{5{\cdot}2\,F}{\angle}}} - 1 \right) \quad \text{.................................(10)}$$

$$F = \frac{\angle \left\{ 1 - \left(\frac{1}{1 + \frac{t}{6\delta}} \right)^2 \right\}}{5{\cdot}2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \ldots (11)$$

$$\delta = \frac{t}{6\left(\frac{1}{\sqrt{1 - \frac{5{\cdot}2\,F}{\angle}}} - 1 \right)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (12)$$

Applying (10) to determine the thickness of Portland cement which would be destroyed by crushing under the pressure arising from 100 fathoms of water column, if employed as tubbing, in a shaft fourteen feet in diameter, we have, on taking the crushing force at 2352 lbs. per square inch—

$$t = 6 \times 14 \left(\frac{1}{\sqrt{1 - \frac{5{\cdot}2 \times 100}{2352}}} \right) = 11{\cdot}18 \text{ inches.}$$

I stated the thickness at about eleven inches, under these conditions, at the last meeting, which was, it will be seen, close upon, but rather within, the true thickness.

If Portland cement were, under the same conditions as to pressure and size of shaft, only loaded at $\frac{2352}{3} = 784$ lbs. per square inch at the inner surface, where the greatest force prevails, that is to say, at one-third of the load required to destroy the material by crushing, it would be necessary, by the same rule, to employ the material

$$t = 6 \times 14 \left(\frac{1}{\sqrt{1 - \frac{5{\cdot}2 \times 100}{784}}} - 1 \right) = 60{\cdot}7488 \text{ inches,}$$

or 5 feet $0\frac{3}{4}$ inch in thickness; while, without going into the calculation, I said it should not be less than 3 feet, which is upwards of 2 feet within the thickness required, in order to reduce the load to 1-3rd of the pressure that would destroy the cement by crushing: so that Mr. Johnson has not any cause to be dissatisfied; at least as regard these statements not having done full justice to the merits of Portland cement.

I should not, however, consider it safe, in so important a position as that of a shaft-tubbing, to load such a material at so much as 1-3rd of the force that would destroy it by crushing: nor do I think it would be altogether prudent to load it at more than one-half of this pressure, or 1-6th of the force required to crush it; and on this principle, if we take

a 14-feet shaft, and a depth of only 50 fathoms below the surface of the water, we obtain by (10)

$$t = 6 \times 14 \left(\frac{1}{\sqrt{1 - \frac{5{\cdot}2 \times 50}{392}}} - 1 \right) = 60{\cdot}7488 \text{ inches};$$

being 5 feet $0\frac{3}{4}$ inch nearly, at the depth of only 50 fathoms, if only loaded at 1-6th of the force required to destroy the cement by crushing.

Taking Portland cement as loaded at 1-6th of the force required to crush it, being $\frac{2352}{6} = 392$ lbs. per square inch, the following table gives the thickness the cement must be on the bed, at different depths below the surface of the water, in shafts of different sizes, according to formula (10):—

Depth below the Surface of the Water in Fathoms.	DIAMETER OF SHAFT IN FEET.				
	8	10	12	14	16
	Thickness of Cement Tub on the Bed in Inches.				
10	3·538	4·422	5·306	6·191	7·076
20	8·002	10·002	12·002	14·003	16·004
30	13·862	17·328	20·794	24·259	27·724
40	22·061	27·576	33·091	38·606	44·122
50	34·714	43·392	52·070	60·749	69·428
60	58·248	72·810	87·372	101·934	116·496
70	131·572	164·466	197·359	230·252	263·144

NOTE.—None of this tubbing should be less than 9 inches on the bed, and some allowance for wear, tear, and chemical action should be added to the thickness given in the table.

When the depth of water exceeds 75·38 fathoms, it will be *impossible* to put in tubbing that will have to sustain only 392 lbs. per square inch at the inside of the tubbing; so that the cement, if used at all below that depth, would require to be pressed or loaded at more than this, which is 1-6th of the force required to crush it: being the load at which the above table is calculated.

Although the above table gives some of the thicknesses near the surface of the water at less than nine inches on the bed, in practice it would not, I consider, be prudent to have even the uppermost courses of less

than that thickness, or they would be liable to be broken, by accidental and other blows, to which tubbing is liable in shafts.

I will conclude by giving a table of what I consider to be proper thicknesses to give to cast iron tubbing in shafts, in order to ensure a proper degree of safety; but suggest that even the uppermost courses should, in no case, be less than half or five-eighths of an inch in thickness, for, although less would bear the mere pressure of the water, there would be, otherwise, too great a liability to fracture from other causes.

I will, in constructing the table, take 12,000 lbs. per square inch as the greatest compression to which the inside of the tub has to be subjected, being about 1-8th of what will crush ordinary cast iron. According to formula (10):—

Depth below the Surface of the Water in Fathoms.	DIAMETER OF SHAFT IN FEET.					
Fathoms.	8	10	12	14	16	18
	Thickness of Metal Tubbing in the Plate, in Inches.					
10	0 106	0·132	0·158	0·185	0·211	0·238
20	0·211	0·264	0·317	0·380	0·422	0·475
30	0·317	0·396	0·475	0·554	0·634	0·713
40	0·422	0·528	0·634	0·739	0·844	0·950
50	0·528	0·660	0·792	0 924	1·056	1·188
60	0·638	0·798	0·958	1·117	1·276	1·436
70	0·749	0·936	1·123	1·310	1·498	1·685
80	0·854	1·068	1·282	1·495	1·708	1·922
90	0·965	1·206	1·447	1·688	1·930	2·171
100	1·090	1·362	1·634	1·907	2·180	2·452

NOTE.—The uppermost courses of tubbing should, in all cases, be at least half an inch thick in the plate; even in shafts of very small diameter; and 5-8ths of an inch thick in shafts of large diameter, or they would be liable to fracture from blows. It seems also to be desirable that a constant thickness should be added to the thicknesses given in the above table, to allow for wear and tear, and for corrosion or other chemical action on the metal.

M. Coombes gives the following rule for finding the proper working strength of cast iron tubbing for shafts:—

$$t = \frac{w\ H\ R}{E\ i}$$

Where t = the thickness of the tubbing in French metres.

w = the weight of a cubic metre of water = 1000 kilogrammes.

H = height of head of water in metres.

R = the radius of the shaft in metres.

E i = 6,000,000 the product of the coëfficient of elasticity into the greatest shortening, in proportion to the length, to which it is intended to subject the material.

This rule reduced to English measures, according to the notation previously employed in this paper, becomes

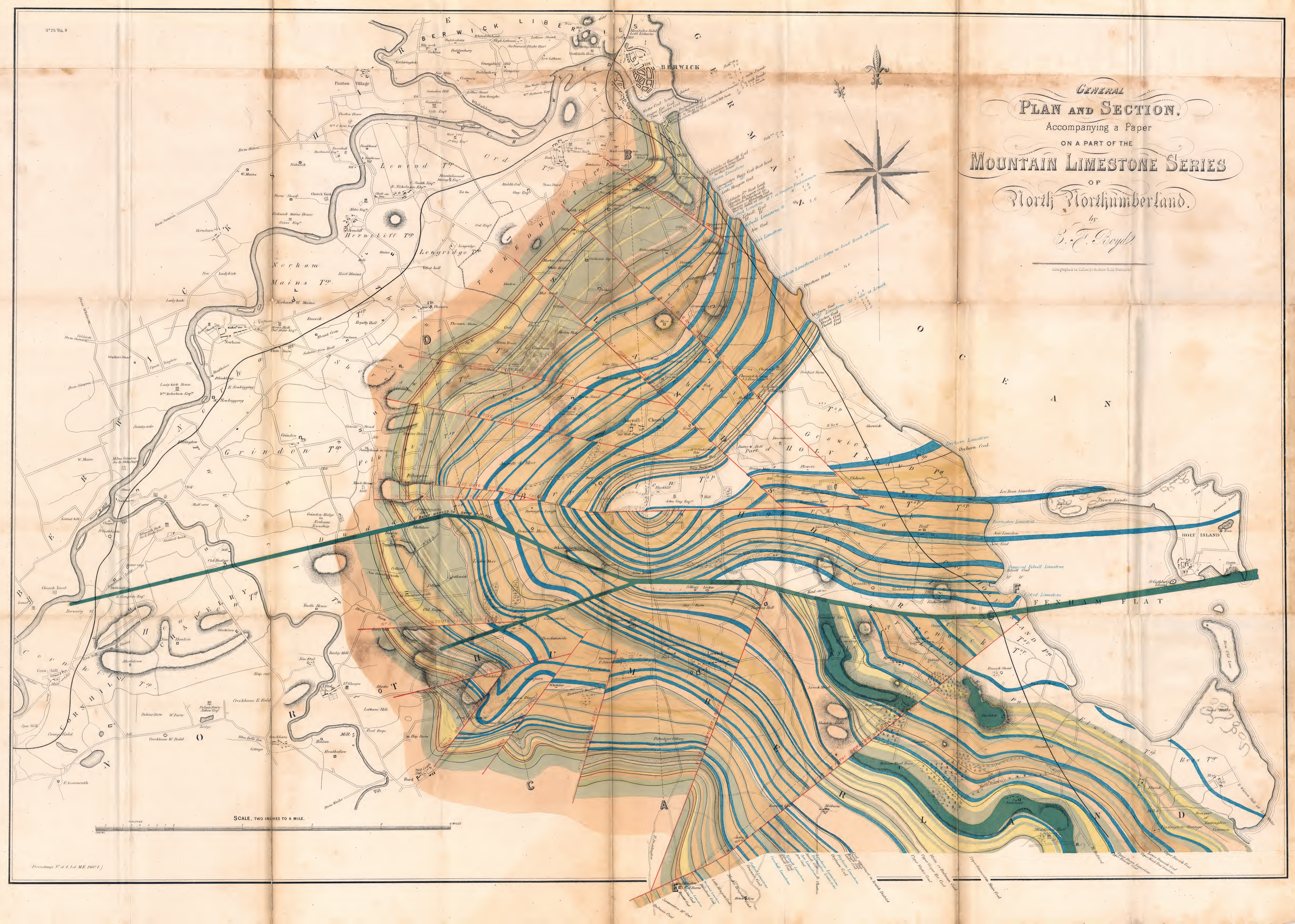
$$t = \cdot 00183\ F\ \delta \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (13)$$

It is based upon taking the average load upon the metal at somewhat less than 1-10th of the ultimate strength of cast iron. This rule is further based upon the somewhat erroneous supposition that the *average* circumferential thrust is the same as the *greatest*, and it gives results much higher than those given in the above table, which is founded upon taking the *greatest*, and not the *average* circumferential thrust, as the ultimate strength of the material, as well as upon loading it higher than Mr. Coombes proposes. According to the latter principle, the thickness of the tubbing requires to be increased in thickness, in a ratio somewhat higher than the mere increase of depth below the surface of the water it has to sustain.

The thickness of tubbing, it may be observed, varies in the same ratio as the diameter of the shaft in which it is employed; so that, for a double diameter, we require to employ tubbing of twice the thickness, to obtain equal strength at similar depths below the surface of the water.

How far Portland cement, if used for tubbing in shafts, would be able to resist the forces due to the expansion and contraction, arising from changes of temperature in a hot upcast, I have not taken the trouble to investigate; but I should be inclined to entertain very grave doubts as to its safety on this score, if even it were of sufficient thickness to resist the mere pressure of the water.

I have not taken any notice of the additional strength imparted to cast iron tubbing by the brackets and flanges, so that any strength due to them will be additional to that calculated for.


N° 25 Vol. 9
General
Plan and Section.
Accompanying a Paper
on a part of the
Mountain Limestone Series
of
North Northumberland.
by
J. F. Boyd.
Lithographed in Colour by Andrew Reid, Newcastle.
Berwick
Holy Island
Fenham Flat
Scale, two inches to a mile.
Furlongs
Chains
Miles
(Proceedings No. of E. I. of M.E. 1869.)

LOWICK VILLAGE

Three Quarter Coal
Copper Eye Coal

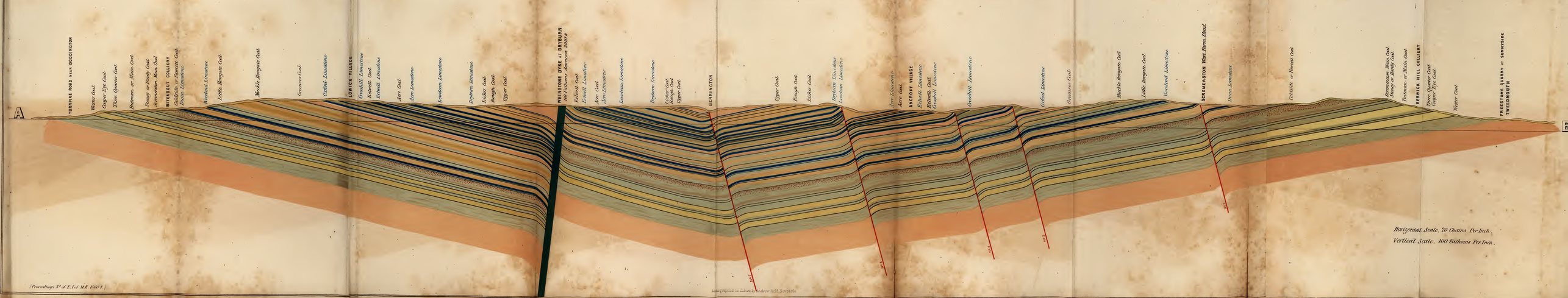
Wester Coal

FREESTONE QUARRY AT SUNNYSIDE
TWEEDMOUTH

Scale, 20 Chains Per Inch.

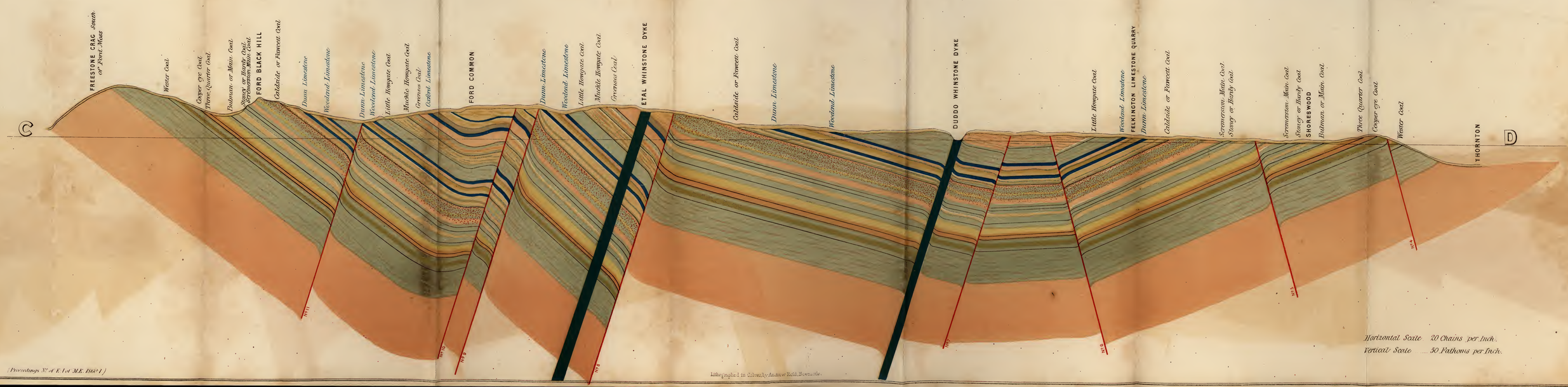
Scale, 100 Fathoms Per Inch.

SECTION OF STRATA FROM A TO B REFERRED TO IN PLAN OF PART OF NORTH NORTHUMBERLAND.



Lithographed in Colours by Andrew Reid, Newcastle.

SECTION of STRATA from C to D referred to in PLAN of PART of NORTH NORTHUMBERLAND.



Horizontal Scale 20 Chains per Inch.
Vertical Scale 50 Fathoms per Inch.

[Proceedings N° of E. I. of M.E. 1860.1]

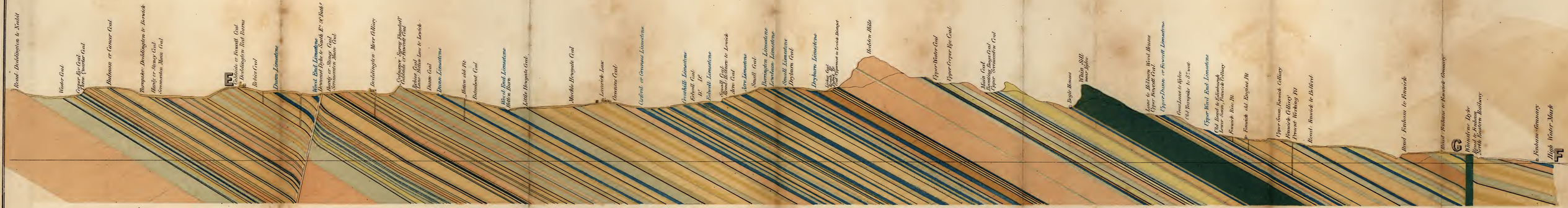
Lithographed in Colours by Andrew Reid, Newcastle.

Horizontal Scale 20 Chains per Inch.

Vertical Scale 50 Fathoms per Inch.

Road. Doddington to Nesbit
Begle Houses
Whin Sill
near Kylee
Road: Fenham to Fenwick Granary
Whinstone Dyke
Road to Fenham
North Eastern Railway
Fenham Granary
High Water Mark

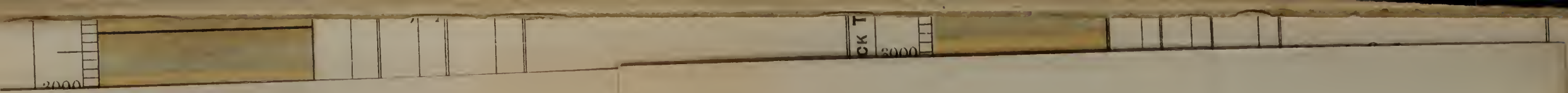
SECTION OF STRATA FROM E TO F ON PLAN OF PART OF NORTH NORTHUMBERLAND.



HORIZONTAL SCALE, 20 CHAINS PER INCH.
VERTICAL SCALE, 50 FATHOMS PER INCH.

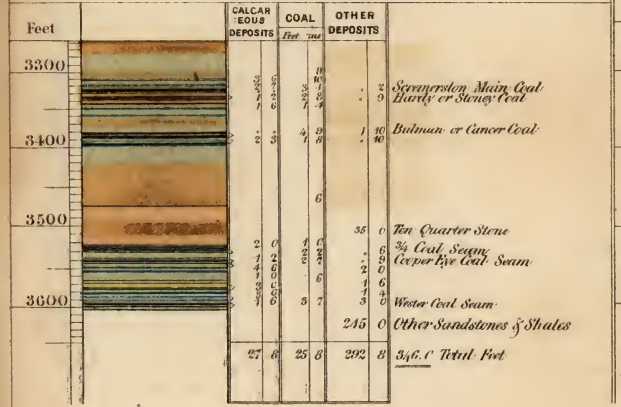
(Proceedings N.s of E. I. of M.E. 1867.)

Lithographed in Colors, by Andrew Reid, Newcastle.



Lithographed in Colors, by Andrew Reid, Newcastle.

SO MUCH OF GENERAL SECTION AS APPEARS AT FELKINGTON NEW PIT.

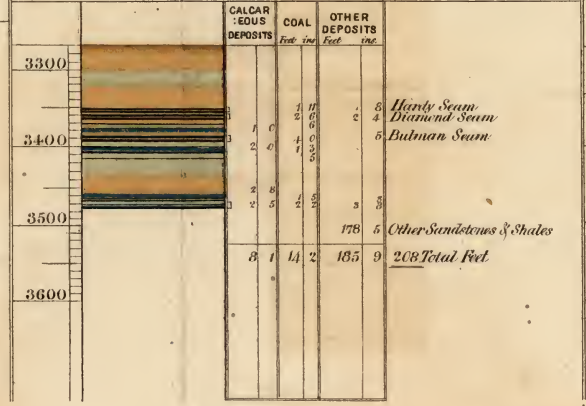


	CALCAREOUS DEPOSITS		COAL		OTHER DEPOSITS		
			Feet	ins	Feet	ins	
						2	Sarnerston Main Coal
						9	Hardy or Stoney Coal
					1	10	Bulman or Cancer Coal
						10	
					35	0	Ten Quarter Stone
						6	¾ Coal Seam
					2	9	Cooper Eye Coal Seam
					2	0	
					1	6	
					3	4	
					3	0	Wester Coal Seam
					245	0	Other Sandstones & Shales
	27	0	25	0	292	0	346.0 Total Feet

SO MUCH OF GENERAL SECTION AS APPEARS AT SHORESWOOD COLLIERY.

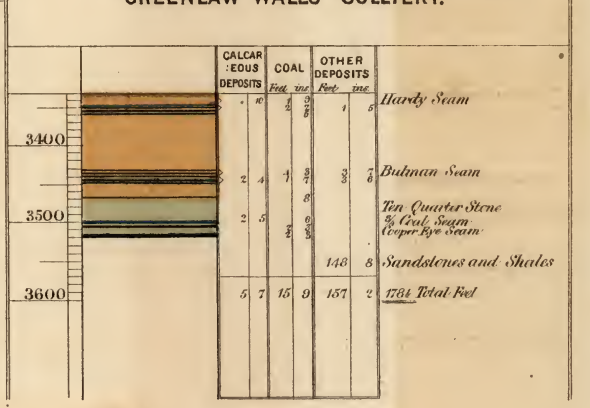
CALCAREOUS DEPOSITS		COAL		OTHER DEPOSITS		
		Feet	ins	Feet	ins	
		4	9	1	6	Bulman Seam
1	3	3	6	3	11	
2	10		9			
		2	2		8	
	5		5			
1	11	1	8			
2	4	1	1		4	¾ Coal Seam
			7		9	Cooper Eye Seam
				228	0	Other Sandstones & Shales
8	7	17	5	235	2	261.2 Total Feet

SO MUCH OF GENERAL SECTION AS APPEARS AT CATHERICK COLLIERY.



CALCAREOUS DEPOSITS		COAL		OTHER DEPOSITS		
		Feet	ins	Feet	ins	
		1	11		8	Hardy Seam
		2	6	2	4	Diamond Seam
1	0		6			
2	0	4	0		6	Bulman Seam
		1	3			
			5			
2	8					
2	5	2	5			
				3	8	
				178	6	Other Sandstones & Shales
8	1	14	2	185	9	208 Total Feet

SO MUCH OF GENERAL SECTION AS APPEARS AT GREENLAW-WALLS COLLIERY.



CALCAREOUS DEPOSITS		COAL		OTHER DEPOSITS		
		Feet	ins	Feet	ins	
				1	5	Hardy Seam
2	4	1			7	Bulman Seam
					6	
						Ten Quarter Stone
2	5					¾ Coal Seam
						Cooper Eye Seam
				148	8	Sandstones and Shales
5	7	15	9	157	2	178¼ Total Feet

3000
Robies Coal
CK TAR
3000
Robies Coal

SECTION OF STRATA

IN DIFFERENT LOCALITIES REFERRED TO IN PAPER ON

CARBONIFEROUS LIMESTONE SERIES

OF PART OF

NORTH NORTHUMBERLAND

by

E. F. Boyd.

SCALE, 200 FEET PER INCH.

GENERAL SECTION.

Feet		CALCAREOUS DEPOSITS ft	CALCAREOUS DEPOSITS in	COAL ft	COAL in	OTHER DEPOSITS ft	OTHER DEPOSITS in	
		1	0					
		3	0					
		14	0					
		13	0					
				2	0			Upper Seam Fenwick Colliery
		1	6					
		2	7			5		Lower Seam Fenwick Colliery
		12	0					Upper Wood End Limestone
		18	0	2	6			Upper Dunn or Fawcett Limestone Upper Fawcett Coal
						132	0	Whin Stone Sill
		10	0					
		1	8					
		4	0	2	7	2	6	Upper Scremerston Coal
				1	0		4	Bursting Bags Coal
				2	0			Main Coal
				1	0			Upper Cooper Eye Coal
		8	6	2	0			Upper Wester Coal
						266	0	Sandstone of a Reddish Tinge
		4	0					Coal: Uppermost in Lowick Series
				2	0			Parrot Coal (Coarse)
				1	8			Rough Coal
				2	6			Licker Main Coal
		20	0					Dryburn Limestone
				1	3			Dryburn Coal
		6	0					Small Limestone
		15	0					Lowdean Limestone
		4	0					Bonnington Limestone
				1	0			Small Coal
		21	0		10			Acre Limestone: Best in Series
				2	0			Acre Coal
				1	2			Small Coal
		8	0					
		18	0	1	3			Edwell Limestone
		5	0	2	0			Edwell Coal Do Do
		8	0	1	0			Crosshill Limestone
		6	0		10			
		8	0					
		6	0	1	2			
		15	0					Carterd or Greenses Limestone
			9	2	6			Greenses, or Allerdean Coal
				3	0			Muckle Howgate, or Woodside Coal
				2	2			Little Howgate Coal
		10	0					Wood End or Biteabout Limestone
					6			
				1	8			Biteabout Coal
		9	0	1	3			Dunn Limestone
				1	7			Robies Coal
				2	4			Caldside or Fawcett Coal
					3			
		1	2		4			
				3	3	3	0	
					9		6	
				1	0			
					7			
					4			
				1	3	7	4	
			8					
		4	10	1	8	2	8	Scremerston Main Coal or Black Hill Seam
			6	4	10		3	
		1	2	1	0		8	Hardy or Stoney Coal
		2	6	4	6	1	3	Bulman or Cancer Coal, or Main Coal
						1	6	
			6	1		2	4	
				1		2	6	
					6			Ten Quarter Freestone
		1	0	1				
		1	6	2			4	Three Quarter Coal
		4	0	2	7		10	Cooper Eye Coal Coal
		1	6		6	2	0	
		2	6			2	0	
		1	6	3	4	3	2	Westrr Coal: Lowest in Series
						2648	4	Other Sandstone & Shales
		277	6	80	0	3223	6	3641 Total Feet

SO MUCH OF GENERAL SECTION AS APPEARS AT FENWICK ENGINE PIT.

CALCAREOUS DEPOSITS ft	CALCAREOUS DEPOSITS in	COAL ft	COAL in	OTHER DEPOSITS ft	OTHER DEPOSITS in	
					9 0	Soil & Gravel
1	0				25 0	Limestone
					35 0	
		2	5		7	Upper Fenwick Seam
1	0	2	5	67	7	71 Total Feet

SO MUCH OF GENERAL SECTION AS APPEARS AT HOLBURN COLLIERY.

CALCAREOUS DEPOSITS ft	CALCAREOUS DEPOSITS in	COAL ft	COAL in	OTHER DEPOSITS ft	OTHER DEPOSITS in	
	2 6					
	3 6					
	1 6	2	6		5	Upper Scremerston Coal Seam
		1	0			Bursting Bags Coal Seam
		2	0			Upper Main Coal or Bulman Seam
				104	7	Other Sandstones &c.
6	6	5	6	105	0	117 Total Feet

SO MUCH OF GENERAL SECTION AS APPEARS AT SCREMERSTON AND BERWICK HILL COLLIERIES.

SCREMERSTON JACK TAR PIT — BERWICK HILL PIT

CALCAREOUS DEPOSITS ft	CALCAREOUS DEPOSITS in	COAL ft	COAL in	OTHER DEPOSITS ft	OTHER DEPOSITS in	
7	0		6			Wood End Limestone
		1	6			Biteabout Coal Seam
7	0	1	0			Dunn Limestone
		1	5			Robies Coal
			8			Caldside Coal
1	2		4			
		3	3	3	0	
			9		6	
		1	1		4	
		1	4	1	1	
	8					
1	2	1	0		3	Scremerston Main Coal
		4	7		6	Hardy or Stoney Coal
		3	1			
		1	0	1	5	
2	9	2	0	1	0	Bulman or Cancer Coal
			6			
	6	1	3	2	2	
			7			
				31	9	Ten Quarter Freestone
		2	0			¾ Coal Seam
1	6	2	7	4	6	Cooper Eye Coal
4	0		8	2	3	
2	0		9			
			6			
1	6	2	4	3	2	Wester Coal
1	6		6		10	
				876	9	Other Sandstones & Shales
30	9	40	6	929	0	1000.9 Total Feet

(Proceedings No of E.I of M.E. 1860-1.

Lithographed in Colors, by Andrew Reid, Newcastle.

ON A PART OF THE CARBONIFEROUS

OR

MOUNTAIN LIMESTONE SERIES

OF

NORTH NORTHUMERLAND.

By E. F. BOYD.

Having been on more than one occasion called upon professionally to report on the probable mineral contents of portions of this district, and having for some years had an opportunity of becoming acquainted with its northern division as proprietor's agent, I have conceived that such a description of its principal features as I could further collect, accompanied by a plan and section, might not be uninteresting as a paper of which to beg the acceptance of your Institute.

Premising, however, that I do not put it forth as an unerring guide to the geologist, but more with that feeling with which all pioneers in untrodden ground are supported, viz. :—That the fact of their jotting down and introducing to the notice of others actual facts which have occurred to them, however vague and unconnected, or undigested, may at some future period assist the more scientific enquirer, or even that flattering sensation which arises from the hope that the opening of a few clearances through the wood may induce others to explore what they may hitherto have deemed impracticable and unapproachable.

Three or four papers have appeared in the "Transactions of the Natural History Society of Newcastle-on-Tyne," which have reference to this district, viz. :—

1st, in Vol. I., No. 15—"Remarks on the Geology of the Banks of the Tweed." By T. M. Winch.

2nd, in ditto, No. 19—"On the Red Sandstones of Berwickshire." By Henry Witham.

3rd, in ditto, No. 28—"On the Geology of Part of Northumberland and Cumberland." By Nicholas Wood.

4th, in Vol. II., No. 6—"On the Stratiform Basalt associated with the Carboniferous Formation of the North of England." By William Hutton.

None of these exactly embrace the district I propose:—

No. 1 being confined to the area immediately north of, and geologically underlying it.

No. 2 treating also of the geological succession immediately beneath.

No. 3 confining its remarks entirely to the coast line of this part of Northumberland; and

No. 4 confining its remarks to one feature of the group.

The scene of my paper may be considered, then, as laid on the line of outcrop of the lower portion of the mountain limestone or carboniferous series, and is classed by Professor Phillips as the lowest portion of the "Upper Palæozoic Strata," in his general classification of British strata.

In my endeavour carefully to track out and delineate the line of outcrop of the several strata forming this group, their general rise to the west and north, enable me to particularize these in pretty regular succession, and as the lowest of them rest throughout upon a very thick stratum of red-coloured sandstone or freestone, described by Mr. Witham as above-named, I have limited the extent of my remarks to the sea coast line and to the points to north, west, and south-west, where the red sandstone appears, which is nearly defined by commencing at the south bank of the Tweed, about three-quarters of a mile south of Berwick, and continuing by the edge of the high ground before descending to the river Till, past Berwick Hill, Shoreswood, and Felkington, through Greenlawalls, Gatherick, Etal, Ford, and Ford Moss, to Doddington, Hetton, Holburn, Middleton, and Belford. And at Belford I leave it, in the hope that, as the necessarily minute attention paid to the alternation of the various strata in the lead-mine districts has long ago clearly developed, through the instrumentality and arrangement of Westgarth Forster and others, the same formation at the head of South Tyne and Weardale, so the advance of railroad communication into North Tyne and Reedwater may call forth the same efforts there, and my humble endeavours may form a link, however small and imperfect, in the exploration

and classification of the north-west outcrop of this interesting geological feature, and in registering its development of the mineral value of the northern portion of Northumberland.

Although displaying almost all of the ordinary characteristics which distinguish the mountain limestone series proper, those aspects wherein this division of it so markedly differs from the same series as witnessed in Derbyshire, Lancashire and Yorkshire, may be noticed, as occurring in two remarkable points, viz.:—1st. That, whereas in these counties, as far north as Craven in Yorkshire, it appears as an immense calcareous mass, nearly undivided, and reaching in several cases to 100 and 150 fathoms in thickness, here, in North Northumberland, its limestones become divided by beds of sandstone and shale, partially accompanied by ironstone and fossil plants, and extensively with coal.

And secondly, again it differs from the before-named instances, in containing numerous and valuable seams of coal, and those useful not only for lime-burning application, but also for household and other purposes.

This development of coal deposit is, however, by no means uniform throughout the district, neither as to quality nor quantity, its northern and western outcrop of the lower strata being more rich in seams of a bituminous and household quality, and supplying, as it does at present, and has done for many past years (probably 200 since its first opening), the fire coal demand for the borders of Scotland; whilst its southern and south-western basset yields a carbon of inferior quality, yet sufficient to burn the extensive lime-beds there so largely apparent.

It, however, assimilates with other members of the carboniferous limestone series, in other respects:—

In the alternation of fossil remains; the limestones producing and even largely composed of marine shells and animals; whilst with the shales and coal beds are discovered the plants and vegetable reliquiæ so universally found to accompany the coal formation proper, leading us to the unmistakeable marino-lacustrine nature of its formation, and to the conclusion that, whether the coal beds were formed from the forests and plants on the site where they vegetated, and were once nourished by the dews and vapours of a surrounding atmosphere, or were the result of deposits from periodical internal fresh water lakes and estuaries, carried there by the waters that held them in suspension, yet these must have been at frequent intervals subjected to violent, extensive, and long-continued inundations of marine floods holding in suspension and again depositing calcareous matter, shells, and debris of marine animal life, broken and disturbed by wide, extended, and violent forces.

FOSSILS.

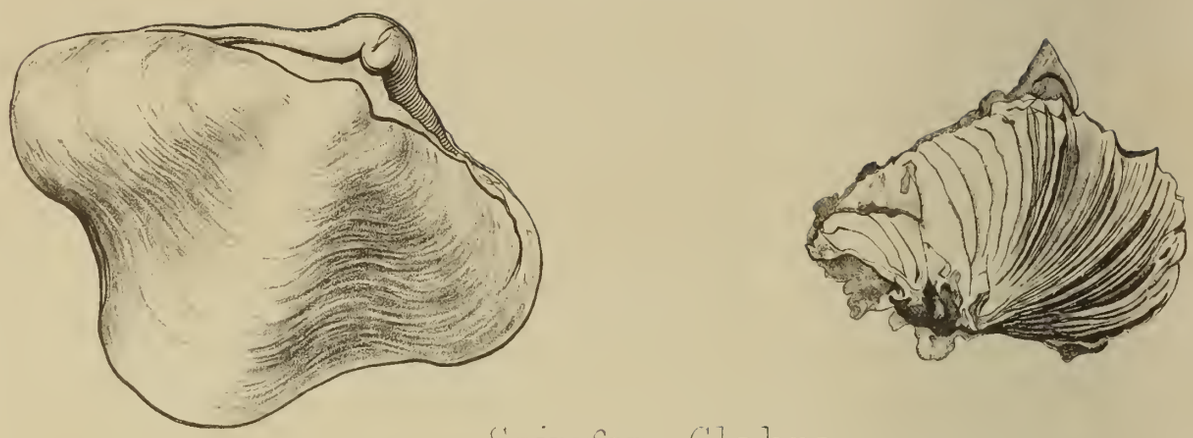
The fossil remains observable in other districts of the carboniferous or mountain limestone, are here met with in considerable abundance: the peculiarity, as before remarked, being the alternation of sandstones, coals, and shales, containing sand and fluviatile remains, with limestones containing numerous specimens of, and even itself largely composed of, marine animals and shells. It preserves, also, the distinctive feature which belongs to the series—that both the terrestrial and marine remains are more unlike the modern productions of nature than those of more recent rocks.

Leaving, then, the difficult question as to the then peculiar state of the atmosphere, and the conditions of land and sea, with the extraordinary inroads, which their entirely different deposits lead us to consider that they must have been permitted to practise upon each other, to more scientific geologists, I may state generally, that the amount of fossil plants met with, is by no means of the same extent as in the coal measures proper, and that they are more narrowly confined to specimens of calamites, stigmaria, sigillaria, and lepidodendra, of which the stigmaria are the most abundant. And that the limestones of this district afford as fine specimens as any others, of encrinites, terebratulæ, spirifiræ, producta, and orthocerata, of corals of various character, and crinoidal remains in abundance.

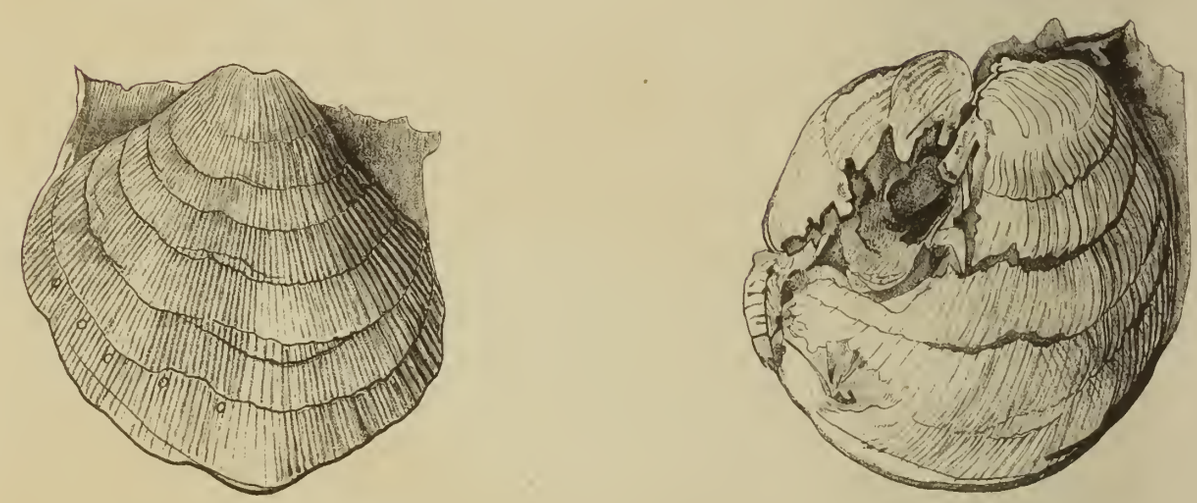
The Low Dean Bed would seem to have furnished the most remarkable both as to numbers and character, and particularly as to orthocerata, sketches of two kinds of which, extending to two feet in length, I beg to introduce, they being now preserved by Mrs. Johnson, of Scremerston Sea House, and obtained from her extensive quarry recently opened out in the said Low Dean bed of limestone, at Sand Banks, near the seashore, two miles to south of Scremerston. The roof of the Cooper Eye Seam being composed of about a foot of coarse limestone, furnished to Mr. George Bailes, agent at Scremerston and Shoreswood Collieries, and to whom I refer in another part of this paper, a rather uncommon specimen of the tooth of a large fish or saurian: it is noticed by Professor Phillips in his work on geology as that of a megalichthys hibberti.

An extensive and beautiful collection of these marine fossils has been made by the Rev. Mr. Jenkynson of Lowick, which have largely assisted to illustrate Professor Sedgewick's different papers contributed to the Geological Society; and they were presented by him and are now preserved in the Woodwardian Museum at Cambridge.

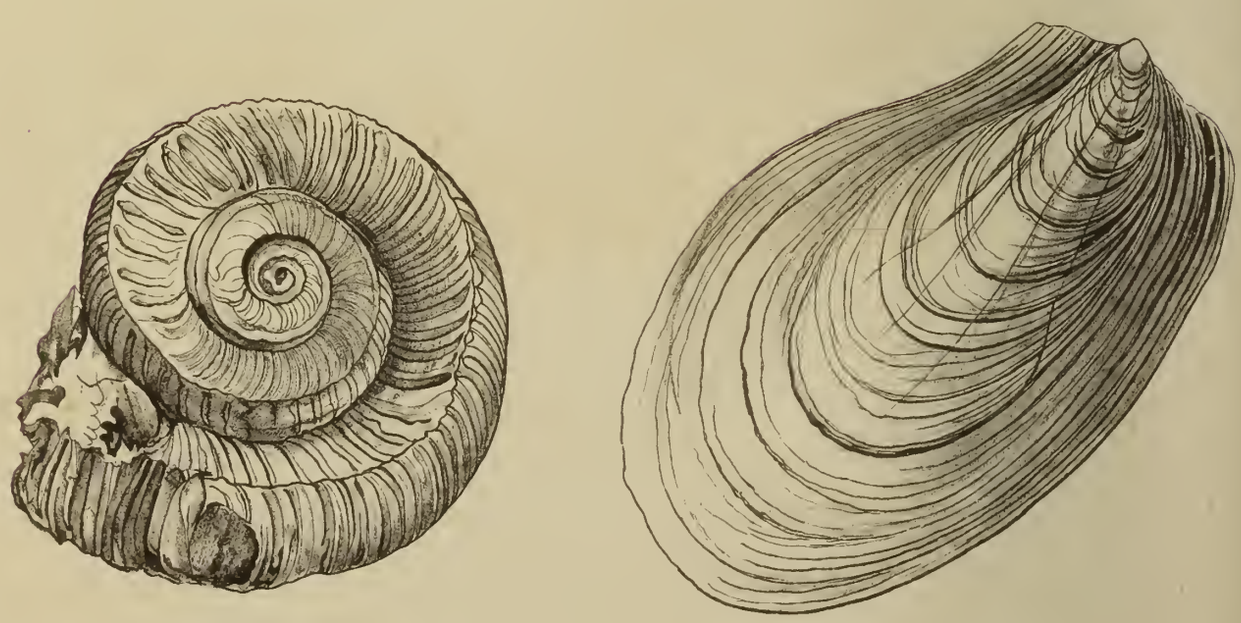
There occur two thin layers of soft shale-like strata, though probably



Spirifer Glabra



Producta

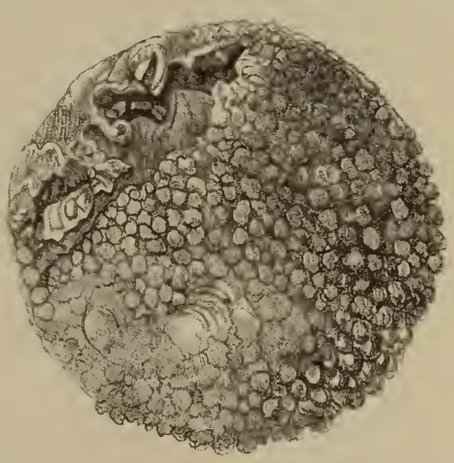


Euomphalus

Posidonia

Ambonychia Triton
cased in Iron pyrites

Syringopora



Ichthyocoprolite

Stems of the Lily or Moniliformis Encrinite

highly calcareous, immediately underlying the Low Dean Limestone, which contain very perfect specimens of encrinites, and amongst the friable material of the matrix, in which they are imbedded, they can be procured of considerable length and very perfect, even to the display of the short branches of this beautiful coral. When broken into short lengths and penetrated in the centre, they form the St. Cuthbert's Beads of the Holy Island fishermen.

Entire layers of limestone are formed of the crinoides and the syringopora.

Again, this district assimilates to others, in the numerous and extensive faults, dykes, or dislocations of the strata to which it is subject. The circumstance of the course of these Slip Dykes being found in general to be at right angles to the main axis of elevation, being here varied to that of being at right angles to the full dip and rise of the strata at the particular part of the district, under consideration, where they occur; and as this varies by slow gradations from due north in the direction of Scremerston, to west and south at Etal and Ford until it becomes due south at Lowick, the whole area assuming, and being thereto somewhat assisted by the occurrence of the Large Dyke at the bottom of the basin, very much the appearance of an upturned shell or fan, fringed by the edging of red sandstone, except at the part where the line of outcrop begins to diverge to its more permanent and unvaried course of south-west throughout the county.

Under the head of Slip Dykes, one very remarkable fact must not be omitted to be named, viz., that (with the exception of a small one of four and a half fathoms, from the line of which the strata on the sea coast between Scremerston Sea House and Tweedmouth dip thence to the east, at a much greater inclination than heretofore, and approaching an angle of 45° due east), the whole of these dislocations numbered on the general plan, up to a point where No. 6 occurs, and near Felkington south boundary, are Rise Dykes to the south-west; and thence to south-west the rest of them are downcast, or depress the strata in that direction—the latter influences elucidating strongly the beneficial result to the dwellers on the surface of what are customarily termed "faults" and "dislocations," and what in common phraseology has been branded with the name of "difficulty" or trouble in this and other similarly situated districts; but which ought rather to be construed to evince the wonderful provision of the Creator in making the earth's surface more beneficially

useful for the habitation and comfort of the creature, by multiplying the edges of outcrop of valuable strata, through the frequent occurrence of these Dip Dykes (as at Berrington, Licker and elsewhere), thus again and again exposing their otherwise hidden products to the energy and enterprise of man.

A short enumeration and description of such principal Dykes as I was enabled to introduce on the plan may not be uninteresting at this stage.

ENUMERATION OF THE PRINCIPAL DYKES MENTIONED ON THE SURFACE PLAN.

Commencing then at the northern extremity adjoining the sea coast:—

1st.—We have a four and a half fathom downcast to west; course N. 30 W.; being the point from which the strata (hitherto rising nearly due north) begin to dip heavily towards the sea; its course and dimensions are determined by the Scremerston sea level passing through it.

2nd.—Rise Dyke to west of 15 fathoms; course N. 20 W.; determined by the west workings of Scremerston and east workings of Unthank Colliery in two or three of the seams.

3rd.—Rise Dyke, south-west, of about nine fathoms; course N. 22 W.; determined by the Murton Colliery workings, also seen in the ravine near Allerdean Mill, where limestones are observed thrown back to west, and deeper.

4th.—Rise Dyke, south-west, of about three and a half fathoms; course N. 33 W.; proved in Shoreswood Colliery workings, and between it and Thornton. In the former towards the east and north it takes the form of a "nip" or "baulk," extending for a long distance (250 yards); the top coal of Cooper Eye Seam being removed and the bandstone and grounds remaining.

Mem.:—These "baulks" or "nips" are very frequent in this class of rocks, two or three being seen to west of Scremerston Shaft, in Caldside and Main Coal Seams.

5th.—Rise Dyke to south-west of fourteen fathoms; course N. 33 W.; apparent in the Felkington workings of Cooper Eye Seam, and has been drifted through recently at Felkington, prior to sinking a new pit there.

6th.—Rise Dyke to south-west of seven fathoms; course N. 58 W.; described by the old plans of Felkington Colliery in rise workings of Cowper Eye Seam.

7th.—Downcast Dyke of twenty fathoms: the first downcast of the

series, except the four and a half fathom Scremerston Sea Coast Dyke, and determined by the necessarily changed position of the pits in the Greenlawalls Colliery, and likewise the outcrop of the lower seams of coal being extended farther west into the country (nearly 400 yards), and close up to the boundary between Felkington and Duddo.

The Upright Basaltic Dyke next appears. Its characteristic and igneous features have been described in another place. The usual width between its perpendicular sides is from six to eight yards—its mineralogical character not differing as to colour, nor in its composition of hornblende and felspar, from other specimens of a like nature. This is the dyke, the course of which appears described on the plan as from Lennel House to Holy Island; and that it must be also a Slip Dyke to south, or have interfered with such a dyke, is clear from its throwing the outcrop of the seams still farther out to the south and west (nearly half a mile). Its surface workings for road material are observable (as indicated on the plan by red ink shading) at Duddo, Mattilees, Licker, Kentstone, Mount Hooly, and on the coast at Fenham.

8th.—Downcast Dyke to south, of at least 109 fathoms, called the Longy Heugh Dyke; course N. 67 W.; determined by tracing the three items of obvious bearing, viz., the workings of the Cooper Eye Seam underground, and of the Ten-Quarter Freestone and Wood End Limestone on the surface; the former of these forming a bold western basset, of thirty or forty feet, throughout the whole of Duddo (the tower standing very high upon it), Greenlawalls, and part of Etal, up to the range of the dyke; and these accompanied by the identification of the unerring guide of the outcrop of the Woodend Limestone being thrown out to the west nearly one and three-quarter mile, where the inclination of the strata is nearly at the rate of 1 in 4, altogether admitting of an admeasurement of 109 fathoms between the rise and dip side of this extraordinary dislocation.

Next in course appears the south-west fork of the Basaltic Upright Dyke, described in its place under Trap Dykes. It has already been named that, from the fact of three seams of coal having been pursued continuously throughout the panel occurring between No 8, Longy Heugh, and No. 9, Slainsfield Dyke, without the interruption of this Whin Dyke, it is concluded, either that its influence discontinues here to the west, or that it does not extend to the surface. Its direction, however, is sufficiently clearly indicated by workings in two places, marked on the plan. At the point where our section crosses it, it does

not appear to interfere with the level of the adjoining strata, but immediately on its coming in contact with the Slip Dyke of Longy Heugh, it continues eastward to mark the line of downthrow to south of all the strata in contact. Neither does this influence leave it on its junction with the main fork at Bowsden, this being proved by the second "input" and working of the Rough Coal and Licker Seams with the Dryburn Limestone, on the south side of this dyke, by Mr. Steavenson, at his Licker Colliery; whilst the same seams, and various other limestone and underlying strata, had already cropped out to the surface at Berrington, one and three-quarter mile to the north of this dyke.

Its effects on the strata further to east, and forming the accompaniments to the great Whin Sill, I have attempted to describe in another place under that head; and whether the frowning battlements of Holy Island Castle are indebted for the sharp-edged and undecaying nature of their foundation rock, to the Whin Sill, or the Upright Basaltic Dyke, may be left for discussion, which discussion may likewise, perhaps, include the question as to the centre of operations of this outpouring of the molten lava, whether at the Fern Islands, the Lammermuir Hills, or at High Teasdale in Lunedale Forest.

No. 9, called Slainsfield Dyke, downcast to south of nearly seventy fathoms; course N. 76 W.; its extent being proved from the circumstance that, on the road between Berry Hill and Watchlaw, and including the space between Dykes Nos. 8 and 9, the outcrop of the last of the seams, viz., the Cooper Eye and Wester Coal is found to have taken place before arriving at No. 9 Dyke, but that, immediately on crossing it to the west of Watchlaw, and at 250 yards to west of last outcrop, the Cooper Eye Seam requires a shaft of fifty fathoms to reach it.

No. 10, Ford Common Dyke, downcast to south; course S. 63 W.
No. 11, Ford Moss, ditto ditto course S. 63 W.
No. 12, Rowten Lynn, ditto ditto course S. 43 W.
No. 13, Doddington, ditto ditto course S. 47 W.
No. 14, Hetton, ditto ditto of ninety fathoms; course S. 75 W.

The exact extent of throw or dislocation of these several dykes, I have, except in the case of the Hetton Dyke, no means of ascertaining. That they do occur, and very nearly in the position and courses described, and that they are, without exception, downcasts to south and east, is sufficiently determined by an inspection of the limestone quarry workings

on the surface, and such coal outcrops and workings as were capable of being examined and traced.

This district again assimilates itself to others of a like geological period, in being intersected by the already noticed Upright Basaltic Dykes, and by the extensive exposure on the surface of the Great Whin Sill, or stratified Basalt. This latter has been so minutely and ingeniously treated by Mr. Hutton, in his paper before the Natural History Society of Newcastle-on-Tyne, vol. II., page 187, that it renders any particular description of mine unnecessary. But in remarking on its entirely igneous character, and its occurrence on the same plane of regular stratification between beds of marine and fluviatile deposition, I am very much inclined to agree with the theory advanced by that writer, that although an intruder amongst such strata, there is little evidence to prove that it was actually *protruded between* beds already consolidated, but that the appearances, so far as I have been enabled to observe, rather favour the idea promulgated by Mr. Hutton, in contradistinction to that of Professor Sedgewick, viz., "that this bed of basalt was produced by an overflowing of lava during the deposition of the Mountain Limestone, after those beds which are found below it, and prior to those above it." The specimen produced, from the lime quarry near Middleton, of the Whin Sill in contact with and overlaid by a limestone bed, does not show that great evidence of the influence of heat upon the limestone, which, in other instances of such contact, becomes whitened and highly crystallised. The non-intrusion of any of the whin or basalt into any fissures or cracks of strata, either above or below (so far as I have had opportunity to observe it), also favours this view of the question.

The course or line of direction of this Whin Sill through the district is matter of interest. It is traced by Mr. Hutton from Helton, in Westmorland, by Cross Fell, Croglin, Tindale Fell, Tyne Head Smelt Mill, Thirlwall, Wall, House Steads, Sewing Shields, Tepper Moor, Gunnerton, Thockrington, Divot Hall, West Harle, Whelpington, Elf Hills, Hartington, Gallow Hill, Forest Burn, Rugley, Alnwick Moor, Ratcheugh Crag, and Craster, to Dunstanborough, where it disappears by east dip and denudation into the sea, to appear again forming the Fern Islands, having hitherto preserved a nearly N.N.E. direction; but on its re-appearance at Bamburgh (where, in the castle well there, it is about ninety feet thick), after permitting the lower limestones and coals beneath it to appear at Beadnell, North Sunderland, and Monk's House,

it assumes a nearly west direction by Spindlestone to Belford, its course being marked by bold escarpments and irregular edges, as at Raven Crag and Boggle Houses (see sketch). At Boggle Houses it presents the longest and loftiest exposed surface, being nearly a mile in length, and displaying on its western face fifty perpendicular feet, showing the prismatic and columnar arrangement; below which the large blocks and debris extend at an angle of 45°, more than 110 feet farther, making its perpendicular height here probably about 130 feet; and being again underlaid by thick beds of reddish sandstone, which, together with the basalt, by these sudden denudations, abut to west, in shape of a continuous north and south escarpment, enclosing the rich lands of Holburn, Hetton, Chatton, and Chillingham. At Kyloe its basset would appear to vere nearly due north; and although its northernmost extremity has been connected, both by Mr. N. Wood and Mr. Hutton, with the Basaltic Rock at Holy Island, yet I find great difficulty in making out a continuous course for it from Kyloe to Holy Island, because the immediate *overlying* of it by successive beds of limestones, coals, shales, and freestones, as at Kyloe Church, Fenwick Colliery, and Fenwick Steads, lead one to the opinion that its further progress north was intercepted by the interference of the Great Slip Rise Dyke to north (numbered 8 on the plan) into the fissure, and direction of which I conceive the Whin or Basaltic Upright Dyke, running from Holy Island to Lennel on the Tweed, to have obtruded itself.

The line of direction of the latter, or Upright Basaltic Dyke, is much more easy to trace. Running from Holy Island Castle slightly north of west to the village of Bowsden, where it is found to separate into two forks, the course of the south branch being denoted by its extensive working for road material at Woodside and Woodend as nearly due west, although I have been unable to identify it farther west than to a plantation on the road leading from Woodside to Hay Farm, the long day-level driven from Berry Hill and between No. 8, Longy Heugh, and No. 9, Slainsfield Dykes, to unwater the western edge of three Etal coal seams, not having recorded its passage through it, and thereby the possibility is suggested of its having ceased to rise at this point to its present surface, as I conceive it to have been joined by, or itself obtruded into the channel of the Berry Hill or No. 8 dyke, it being identified with the downthrow of the strata to south of 100 fathoms. The northern fork, from Bowsden, runs N. 42 W. nearly to Mattilees, where it has been extensively wrought for the roads, nearly west to Duddo Tower, a

little to north of which it is also extensively wrought as road material, and thence leaves our district at a point a little south of Grindon Ridge, crossing the Till a little north of Tiptoe, and the Tweed at Lennel House, to north of Coldstream. The remarkable circumstance of its uniformity of appearance, its uprightness, and preservation of its perpendicularity through all descriptions of rock—its not altering the level of those through which it passes, (except as before described, where it appears to have joined the course of a Slip Dyke)—the fact of its invariably reducing the coal into charcoal, the limestones into a sort of marble, the sandstones to vitreous jasper, and depriving the shales of their bitumen, and their wonderful stretch across country with so slight a variation in their courses, render them to the eye of a geologist one of the most remarkable phenomena he is called upon to witness.

A feature of great interest connected with this upright Basaltic Dyke I must not omit to record, because it may lead to further consideration regarding the relative ages of the Whin Sills and Basaltic and Slip Dykes, and it is this:—That near the point where the Duddo Basaltic Quarry is wrought there is known to exist a set of three Slip Dykes or troubles in the coal workings adjoining, and exactly at this place in the quarry the basalt is found to be shifted or removed sideways from its course, but without alteration of the width of the basalt, and, according to the influence or power of the interfering Slip Dyke, to the extent of eighteen feet or as far as thirty feet, pursuing immediately after its original direction. If then the epoch of the upheaving of the Upright Basaltic Dyke may be conceived to be more recent than the deposition of the Whin Sill, which its extra igneous effect on the adjoining strata lead one to imagine, and if coeval with, or very recently subsequent to the date of the other Slip Dykes around it, it would indeed be interesting to have been allowed the opportunity of seeing whether it would have, in a similar manner penetrated through the Whin Sill, or what other effect it would have produced upon it.

At this point it may be well to refer to, or introduce the general section of the whole series, as taken from admeasurements in successive layers of limestone, freestone, &c., apparent in quarries, ravines, &c., and and from colliery sinkings ranged in the order of their superposition. Craving indulgence, however, as to its perfect accuracy, from the difficulties presented in so wide a field by the want of local data of observation, and from the necessary variableness in thickness and relative position of the several strata of which it is composed, in the different parts of the district embraced.

The enumeration of strata which I first prepared commenced only at a point a short distance above the Rough and Licker Coal Seams; this was done so under the impression that the district to be embraced would be confined so far to the north as to have been limited to those beds as the uppermost of the group, and so properly described, but the including of the Kyloe Hills requires that it should commence at the sea shore, near Fenham, and so extend westward by the basset of the Whin Sill and thick freestone below it, forming the lofty Heddon Hill, beneath which the Rough and Licker Coals shortly appear (see the general section). But owing to the thickness of the rich alluvial matter which overlies the outcrop of these strata from the seaside up to Detchant, and reposing, as it were, on the back of the Whin Sill, together with the highly cultivated condition of the surface soil there, I experienced great difficulty in distinctly classifying the series upwards from this point. I have, however, by a careful observation of the several bassets, the sinkings at Fenwick and Detchant, and the notice of such denudations or escarpments as presented themselves by rivulets, quarries, &c., been enabled to complete the section upwards to within a short distance of the sea shore (see the upper part of general section).

Not omitting to record another difficulty in such classification, viz., that under the impression that the thick sandstone or freestone of Heddon Hill were identical with those represented in the general section as underlying the whole series, as at Tweedmouth, &c., and thrown up in this locality by a huge Upcast Slip Dyke, the neighbourhood has designated the seams of coal overlying the Whin Sill by the same successive catalogue of names as those immediately reposing on the red sandstone proper.

Within the series overlying the Whin Sill, I have been enabled to identify five layers of limestone. Two of these cross near the village of Kyloe, and so southwards through the thick woods of Fenwick and Detchant; other two beds of limestone overlie the Fenwick Coal Seam near Fenwick Granary—passing near to Smeafield, to west of Easington Mill, and so to Warrenford Mill; and the fifth observable in the mill race, at Ross Mill, and largely quarried and burnt at the opposite side of the water in Budle Bay.

A small seam of coal is likewise met with in the Mill Race, at Ross Mill, underlying the above-named limestone bed.

The whole of these are intersected and altered in their outcrop by the interference of the large Ninety-Fathom Hetton Dyke.

The further exploration of those beds overlying the Whin Sill is hindered

by the sand banks forming the sea coast line to the east, by the curve to the south-east which here occurs in the Whin Sill, forcing the overlying strata east back into the sea at Budle Bay, and to the north, as before stated, by their being intersected and thrown out by the Upright Basaltic Dyke, conceived by me to be a Rise Dyke of considerable magnitude to the north.

The rich and valuable character of this tract of land between Belford and Fenwick, skirted by the whinstone to west and south, and the sea to the east, clearly evidences how the geology of a country (particularly if composed of debris from basalt, lime, freestone, and shale—here intimately combined) affect the quality and quantity of the agricultural produce of the surface, almost irrespective of climate and aspect.

ENUMERATION OF STRATA.

Remarks.		Coal.	Calcareous Deposits.	Other Deposits.	Aggregate Depths.
		Fms. Ft. In.	Fms. Ft. In.	Fms. Ft. In.	Fathoms.
Commencing at point marked G on General Plan and Section, where the Basaltic Dyke is crossed by Section line from E to F.	Alluvial Matter, Soil, &c.	....	....	1 3 0	
	Shale	....	....	3 0 0	
	Limestone	....	0 4 0	....	
	Freestone	....	....	7 0 0	
	Shale	....	....	4 4 0	
The road from Fenham to Fenwick is constructed on this panel	Red Sandstone	....	....	12 3 0	
	Limestone	....	0 3 0	....	
	Shale and Freestone	....	....	15 0 0	
Formerly quarried to south-east of Fenwick Village, runs to east of Smeafield near Easington Mill, and so to Warrenford Mill	Limestone	....	2 2 0	....	47
	Shale	....	....	6 2 0	
Observable in Brook crossing turnpike road from Fenwick to Belford	Freestone	....	....	11 4 0	
Passes near to Smeafield, to west of Easington Mill, and thence to Warrenford Mill	Limestone	....	2 1 0	....	
	Shale	....	....	4 0 0	
Wrought at present working Pit, Fenwick Colliery	Upper Coal—Fenwick Colliery	0 2 1	....	....	71½
	Freestone	....	....	6 0 0	
	Shale	....	....	2 4 0	
	Freestone with layers of Shale and 1 Thin Limestone	....	0 1 6	14 0 6	
Wrought by perpendicular shaft at Fenwick Colliery, depth 32 fathoms: unwatered by day level in the Ravine at Mount Hooly, and used as household coal in the district	Lower Coal—Fenwick Colliery	0 2 6	....	0 0 5	95½
	Shale	....	....	1 5 0	
Quarried near to Kyloe Village, to south, from whence it ranges southward through Fenwick and Detchant Woods	Limestone, (Upper Woodend Stone)	....	2 0 0	....	99
	Red Sandstone	....	....	3 3 0	
	Shale	....	....	1 2 0	
Passes to south-east of Kyloe, and trending southwards, is quarried to east of Holburn Wood Houses	Limestone, (Upper Dunstone)	....	3 0 0	....	107
	Freestone	....	....	0 3 0	
Wrought years ago in front of Holburn Wood Houses	Upper Fawcett Coal	0 2 6	....	....	108
	Grey and Blue Freestone	....	....	4 3 0	
Varying considerably in its thickness in different situations, and still more so in its exposed basset. It is at Boggle Houses, 132 feet.—Presents the most bold escarpments at Dunstanborough, Bamburgh, Spindlestone, Ravencrag, and Kyloe	Whin Sill	....	....	22 0 0	134
	Shale and Limestone	....	1 4 0	1 2 6	
Hard and gritty, and from the friable nature of the underlying strata is generally seen standing out in naked escarpments	White Freestone with Layers of Shale	....	....	24 5 0	
	Limestone	....	0 1 8	....	
	Sandstone (soft white) and Shale	....	....	6 0 0	
	Two layers of Limestone intermixed with Shale	....	0 4 6	1 0 6	
	Carried forward	1 1 1	13 3 8	155 2 11	170

ENUMERATION OF STRATA.—CONTINUED.

Remarks.		Coal.			Calcareous Deposits.			Other Deposits.			Aggregate Depths.
		Fms.	Ft.	In.	Fms.	Ft.	In.	Fms.	Ft.	In.	Fathoms.
	Brought forward	1	1	1	13	3	8	155	2	11	170
These seams of coal all wrought at Detchant Coal Houses, and at present at Holburn Colliery	Upper Scremerston Coal	0	2	7	....			0	0	4	171
	Sandstone, with two layers of Shale	....			....			3	4	0	
	Bursting Bags Coal	0	1	0	....			....			
	Sandstone and Shale	....			....			3	0	5	
	Main Coal, or Upper Bulman seam	0	2	0	....			....			178
	Red Sandstone	....			....			10	0	0	
	Shales	....			....			7	3	0	
The line of little pits to west of the Moss at Detchant, show the outcrop of these two seams	Upper Cooper Eye Coal	0	1	9	....			....			196
	Two layers of Shale with White Sandstone between	....			....			7	4	0	
	Upper Wester Coal	0	2	0	....			....			204
Old Lime Kilns to west of Detchant Coal Houses show that it has been wrought there	Sandstone	....			....			1	2	9	
	Limestone	....			1	2	6	....			206½
	Shale	....			....			4	2	0	
Forms the bluff and lofty hills immediately to east of Lowick Village, which trending southward, leave the rich lands of Holburn, Hetton, Chatton, and Chillingham to west	Very thick Stratum of Sandstone of a reddish tinge, and highly gritty, and with thin layer of Shale near middle	....			....			44	2	0	
	Limestone	....			0	4	0	....			
In this panel occur the Pits of Lowick Forest, ranging nearly north and south, which, when in operation, probably worked the Licker and Rough Coals — The uppermost coal seam in Lowick district	Coal	0	2	0	....			....			256½
Not fit for lime burning	Freestone	....			....			1	0	0	
	Coal (Coarse Parrot)	0	2	6	....			....			
	Sagger Clay—Metal	....			....			0	2	6	
A coarse coal, only consumed for lime burning; worked at Licker Colliery	Freestone	....			....			0	3	4	
	Rough Coal Seam	0	1	8	....			....			
Wrought for landsale purposes at Licker and Chiswick Collieries	Freestone and Shale	....			....			2	3	6	
	Licker Main Coal	0	2	6	....			....			262
In this panel is situated the "Cook House Freestone," of 20 feet thick, wrought at Haggerstone Quarry, and of which Haggerstone Castle is built	Freestone	....			....			9	2	0	
The uppermost limestone at Lowick, where, and at Licker and Bowsden, it has as yet only been developed.—Colour, light brown	Dryburn Limestone	....			3	2	0	....			274½
Has been wrought at Dryburn	Reddish Brown Freestone	....			....			4	3	0	
	Dryburn Coal	0	1	3	....			....			279½
	White Freestone	....			....			4	0	0	
	Small Limestone	....			1	0	0	....			
Wrought at Sand Banks, Scremerston, and has in it the finest and rarest specimens of marine fossils.—Colour, bright blue	Freestone	....			....			8	4	0	
These layers of shale are probably highly calcareous, and are very redundant of specimens of Encrinites in great perfection	Lowdean Limestone	....			2	3	0	....			295½
Varies much in thickness, and only found in some parts of district	Freestone, with two thin layers of Soft Shale	....			....			1	5	0	
	Berrington Limestone	....			0	4	0	....			
	Freestone	....			....			2	3	0	
	Small Coal	0	1	0	....			....			
	White Freestone	....			....			10	0	0	
	Carrried forward	4	3	4	23	1	2	282	5	9	310 4 3

ENUMERATION OF STRATA.—CONTINUED.

Remarks.		Coal.	Calcareous Deposits.	Other Deposits.	Aggregate Depths.
		Fms. Ft. In.	Fms. Ft. In.	Fms. Ft. In.	Fathoms.
	Brought forward	4 3 4	23 1 2	282 5 9	310 4 3
Best limestone in the series;—In the upper section, generally of pale yellow or dun colour. Yields specimens of Encrinites, Producta, Orthocera, and Bivalve Shells in great abundance, particularly at Ancroft Stead Quarry	Acre Limestone	....	3 3 0	....	314
	Coal	0 0 10	....	....	
	Sandstone and Shale	....	....	3 0 0	
	Acre Coal	0 2 0	....	....	
	Freestone, with thin layer of Shale	....	....	4 3 0	
	Lower Small Coal	0 1 2	....	....	
	Freestone	....	....	3 4 0	
	Limestone	....	1 2 0	....	
	Freestone, intermixed with Bands of Shale and Ironstone	....	....	10 0 0	
Its principal place of working is Saltpanhow; ranks next to Acre in quality, and like the Acre partakes of a dun colour in higher section of the deposit	Eelwell Limestone	....	3 0 0	....	340½
	Freestone	....	....	0 5 0	
	Eelwell Coal (No. 1)	0 1 3	....	....	
	Freestone	....	....	1 5 0	
	Limestone	....	0 5 0	....	
	Shale	....	....	0 2 0	
	Eelwell Coal (No. 2)	0 2 0	....	....	345
	Freestone	....	....	4 4 0	
	Shale	....	....	1 5 6	
	Crosshill Limestone, with Coal Seam overlying it, but separated by Shale Band	0 1 0	1 2 0	0 1 6	353
	White Freestone	....	....	3 0 0	
	Shale	....	....	2 2 6	
	Limestone	....	1 0 0	....	
	Shale	....	....	0 5 0	
	Coal	0 0 10	....	....	
	White Freestone	....	....	4 3 0	
	Limestone	....	1 2 0	....	
	White Freestone	....	....	2 2 0	
	Limestone	....	1 0 0	....	
	Shale and Freestone	....	....	1 2 0	
	Coal	0 1 2	....	....	
	Shale	....	....	1 5 0	
Quarried largely by Mr Sibbit at Greenses, and is one of the most extensively worked in the district; ranges from 12 to 18 feet in thickness	Oxford Limestone or Greenses	....	2 3 0	....	375½
	Red Sandstone	....	....	6 1 0	
	Limestone	....	0 0 9	....	
Wrought by Mr. Sibbit, at Allerdean, for household landsale; and elsewhere for burning Oxford limestone	Greenses or Allerdean Coal	0 2 6	....	....	382
	Shale	....	....	3 2 0	
	White and Brownish Freestone, interstratified with thin layers of Shale	....	....	18 0 0	
	Shale	....	....	6 0 0	
	Carried forward	6 4 1	39 0 11	363 4 3	409 3 3

ENUMERATION OF STRATA.—CONTINUED.

Remarks.		Coal.			Calcareous Deposits.			Other Deposits.			Aggregate Depths.		
		Fms.	Ft.	In.	Fms.	Ft.	In.	Fms.	Ft.	In.	Fathoms.		
	Brought forward	6	4	1	39	0	11	363	4	3	409	3	3
Wrought at Woodside, Biteabout, and Hetton; quality pretty good	Muckle Howgate or Woodside Coal	0	3	0	....			....			410		
	Freestone	....			....			21	3	0			
	Shale	....			....			3	0	0			
Where wrought, consumed chiefly for lime burning	Little Howgate Coal	0	2	2	....			....			435		
	Shales	....			....			11	0	0			
Ranges in section from 14 feet (at Allerdean) to 7 feet	Woodend or Biteabout Limestone	....			1	4	0	....			447½		
	Shale and Sandstone, with two little Coal Seams	0	1	0	....			6	5	0			
Increases to 2 feet 2 inches, at Biter Bit Colliery	Biteabout (or Biter Bit) Coal	0	1	8	....			....					
	Alternations of Freestone and Shale	....			....			9	0	0			
Variable in thickness—reaches 12 feet at Hetton—quality, inferior as compared with the limestones higher in the series	Dun Limestone	....			1	3	0	....			465½		
Almost universally accompanies the Dun limestone	Dun Coal	0	1	3	....			....					
	White Freestone, interlayered with thin Bands of Shale	....			....			9	2	0			
Quarry in it on the Sea Coast	Freestone, Soft White	....			....			13	1	0			
	Robies Coal	0	1	7	....			....					
Richardson Stead Quarry carried on in this freestone	Shale	....			....			7	2	0			
	Freestone, Hard White	....			....			3	2	0			
	Shale	....			....			2	0	0			
Varies in thickness from 4 inches, to 2 feet 6 inches, and 3 feet; is of a fair bituminous though not rich household quality, and has been wrought in almost all parts of the district	Caldside or Fawcett Coal Seam	0	2	4	....			....			501½		
	Shale, with layers of Coal and Sandstone	0	0	3	....			8	2	0			
	Red Sandstone	....			....			2	4	0			
	Shale	....			....			4	1	0			
	Limestone and Coal	0	0	4	0	1	2	....					
	Shale, interstratified with Beds of Sandstone	....			....			10	2	0			
	Three thin Seams of Coal, divided by Bands of Shale	0	3	3	....			0	3	0			
	Alternations of Shale and Sandstone, intermixed with 10 layers of Coal, the total thickness of which amount to	0	3	11	....			16	4	1			
	Dark Red Sandstone	....			....			4	1	0			
	Shale, with layer of Limestone and of Coal	0	0	8	0	0	8	1	3	0			
	Three layers of Limestones and two of Coals with Shale intermixed	0	1	6	0	5	1	0	4	3			
Called also the "Black Hill Seam," at Ford Moss and other places. Is found in finest condition at Scremerston Colliery, where the produce from it is on an extensive scale	Scremerston Main Coal	0	4	0	....			0	0	3	554		
	Shale	....			....			2	4	0			
Only a moderate seam, being coarse burning and difficult of working by reason of its thick band and hardness of the kirving	Hardy or Stony Coal	0	2	7	0	0	6	0	0	8	557½		
	Sandstone and Shale, with layers of Limestone and of Coal	0	1	0	0	1	2	4	2	10			
	White Sandstone	....			....			8	0	0			
	Shale	....			....			1	5	0			
	Carried forward	11	4	7	43	4	6	516	2	4	571	5	5

ENUMERATION OF STRATA.—Concluded.

Remarks.		Coal.			Calcareous Deposits.			Other Deposits.			Aggregate Depths.		
		Fms.	Ft.	In.	Fms.	Ft.	In.	Fms.	Ft.	In.	Fathoms.		
An excellent steam coal by reason of its hard splinty nature. Only at present working at Greenlawalls Colliery	Brought forward	11	4	7	43	4	6	516	2	4	571	5	5
	Bulman, Cancer, or Main Coal	0	4	6	....			0	1	3	573		
Called the Ten-Quarter Stone. Forms the bold escarpments to west in Greenlawalls and Etal Estates	White Freestone, with six thin seams of Coal and three of Limestones	0	3	4	0	3	0	8	0	0			
	Shale, Sandstone and Coal	0	0	6	....			2	4	5			
	Hard Red, and White Freestone	....			....			4	2	0			
	Shale and Limestone	....			0	1	0	1	1	2			
	Coal	0	1	0	....			....					
Not at present in operation at any Colliery in the district, but has previously been wrought to some extent in almost every one of them	Shale	....			....			0	2	9			
	Three-quarter Coal, with Band	0	2	3	....			0	0	4	591½		
Largely composed of Marine Shells	Shale	....			....			2	0	1			
Best household coal of the district; worked most extensively at Shoreswood and Felkington Collieries	Limestone	....			0	1	6	....					
	Cooper Eye Coal	0	2	7	....			0	0	10	594½		
	Shale, with one bed of Freestone, five layers of Limestone, and four of Coal	0	1	11	1	2	0	9	3	2			
Lowest coal seam of the series. Worked at Etal and Ford	Wester Coal Seam, with Bands of Limestone and Shale, making total thickness 8 feet	0	3	4	0	1	6	0	3	2	607		
	Total	15	0	0	46	1	6	545	3	6	606	5	0

COLLECTED ACCOUNT

	Fms.	Ft.	In.		Ft.	In.
Of Coals	15	0	0	or	90	0
Of Calcareous Deposits	46	1	6	,,	277	6
Of other Deposits	545	3	6	,,	3273	6
Aggregate Thickness	606	5	0	or	3641	0 Feet

GENERAL DESCRIPTION OF THE WORKABLE SEAMS OF COAL THROUGHOUT THE DISTRICT.

1.—Rough Coal.—Roof, strong freestone.

	Ft.	In.
General Section, about.....	1	8

A coarse coal, only fit for lime burning.

The Rough Coal.—The highest workable seam in the series of the Lowick district. It is wrought by Mr. Steavenson at his Licker Colliery, being, as its name denotes, coarse in quality, and only wrought to prolong the duration of the seam below it.

2.—Licker Coal.—Roof, strong blue metal.

GENERAL SECTION.

	Ft.	In.
Coal, with partings	2	6

This is the only seam of any importance overlying the thick strata of upper limestones of the general section, and lies about 13 fathoms above the uppermost of them.

This seam forms the principal produce of Mr. Steavenson's Colliery, situated at Licker, where he disposes of it as a landsale coal. The extent between the dyke to north and its south outcrop is very limited. It is highly bituminous in some of its layers, but leaves a large residium of white ash after burning. It was once opened at Chiswick, and drained by a day-level from the sea.

3.—Greenses Coal, called also Allerdean.—Roof stone, red freestone.

	Ft.	In.
Coarse Coal	2	6

Lies about 6 fathoms below the Oxford Limestone.

Although there is almost universally a small seam of coal underlying each limestone bed, more or less adjacent to it, and that the extensive beds of limestone, viz., the Dryburn, Lowdean, Acre, and Eelwell, are each of them so underlaid, yet this seam called the Greenses, and underlying the Oxford Limestone about 6 fathoms, is the first of sufficient thickness to have been wrought for household use, which was done on the Allerdean estate by Mr. Sibbet.

4 & 5.—The Muckle Howgate and Little Howgate.

The former about 3 feet and the latter 2 feet 2 inches in thickness, and respectively about 12 and 40 fathoms above the well-known Woodend Limestone. Have both been wrought to south and to the east of the present Scremerston Pit, in Mr. Thompson's farm.

These seams wherever opened at Scremerston, Felkington, and Woodend, have always been so because of the demand for burning the rich deposits of lime found to accompany them; and this happy distribution may in part account for the favourable improvements in agriculture suggested in these districts, as compared with similar limestone deposits unaccompanied by coal seams.

6.—Caldside or Fawcett Coal.

Usual Section, about 2 feet 6 inches to 3 feet, and occurring about 40 fathoms below the Woodend Limestone. The Dunstone Lime being the only one between.

This seam, though wrought at the older shafts in Scremerston, has not been found in good condition at the present pit. It was won by means of a water-level drift carried up from the seaside, through the entire of Scremerston estate, on to Unthank, a distance of fully 2 miles. For many years this seam continued to supply the landsale vend requirements of Etal Colliery, in that district of it called the Longy Heugh Cut, and there called the Fawcett Coal. It likewise was wrought near the Woodend Limestone Quarry, and on the east side of Fawcett Moor, whence it takes its usual name: and its working is continued through Ford, Doddington, and Biteabout, there supplying a fair bituminous, though not very rich coal, for household landsale.

7.—SCREMERSTON MAIN COAL (generally except at Scremerston and Unthank), termed the BLACK HILL SEAM.

USUAL SECTION.

	Ft.	In.		Ft.	In.
Good Coal	2	4	to	2	8
Ground Do.....	0	6	„	1	3

Near the bottom of the seam is sometimes found a brassy band, and occasionally a coarse or danty coal between the top and ground coals, increasing to band of 6 to 9 inches thick.

It occurs about 90 fathoms below the Little Howgate, and at the last deep winning at Scremerston it is, from the surface, 113 fathoms.

The top coal of this seam, at Scremerston and Unthank Collieries, has for nearly a century supplied the large blocky coal fit for the distant carriage of the borders of Scotland, having been drained for that purpose by a long level, commencing at the sea-side, on the Scremerston estate, a little to north of the Sea House there. Beyond these it acquires the name of the Black Hill Seam, from a place of that name on Ford Moss. It has also been wrought at Felkington Old Lime Kilns; near the Whin Dyke on Mattilees estate; near the Etal Plantation Houses; at Slainsfield, Blackhill, and Doddington. It is, however, in finest condition at Scremerston Colliery, where the annual output reaches about 25,000 tons.

8.—STONY COAL OR HARDY SEAM.—An indifferent seam, being hard and coarse burning, not more than 2 or 3 fathoms below the last-named seam.

USUAL SECTION.

	Ft.	In.	Ft.	In.
Coal.....	....		0	9
Stone Bands	0	9	....	
Middle Coal, good.....	....		1	2
Bastard Limestone Bands	1	2	....	
Bottom Coal, rich and bituminous.....	....		0	9
	1	11	2	8

Hard thill for kirving.

At Greenlawalls and Slainsfield, where it has been wrought, it takes the name of Hardy Coal, and that of Kiln Coal at Ford. The thickening of the band and hardness of the kirving are strong objections to its extensive working.

9.—CANCER COAL, of Berwick Hill; or BULMAN COAL of Murton; and MAIN COAL of Thornton, Shoreswood, &c.

USUAL SECTION.

Tender shale roof.

	Ft.	In.	Ft.	In.
Top Coal	....		1	0
Chalkstone	0	1	....	
Fine Splint	....		1	0
Rough or Coarse Coal....	....		0	7
Band	1	8	...	
Good Coal	....		1	6
Chalkstone	0	1	....	
Bottom or Smithy Coal ..	....		0	4
	1	10	4	7
Shoreswood.....	1	0	4	9
Murton	1	0	4	0
Gatherick	1	0	3	3
Ford.....	0	9	3	5

By reason of its splinty character, this seam produces an excellent steam-raising coal, they binding and hardening it so as to render it of good endurance.

It is now exhausted within the ordinary drainage of the engine power hitherto employed at Ford and Etal, where, but for its difficult roofstone, its winning on a more extensive scale would be resorted to, it being considered of the best sample of steam and household coal, some parts of the seam greatly resembling in hardness and durability the Cooper Eye Seam.

Its working at present is confined to the Greenlawalls Colliery.

10.—THREE QUARTER COAL.—Usual Section, where in best order.
Blue shale roof.

	Ft.	In.
Top Coal	1	1
Black Danty Band	0	4
Coarse Grey Coal	0	6
Bottom Coal	1	1
	3	0

The kirving is made in the shale below. It lies about 18 fathoms below the Bulman Seam.

Although not at present being wrought at any of the already-named collieries of the district, it has borne its part in the working of almost every one of them, and particularly at Slainsfield and Ford Common; and but for its heavier labourage payments and difficult roofstone, would, by reason of its coal bearing well the effects of weather and carriage, prove a valuable adjunct to the household and steam purposes of the district.

11.—COOPER EYE SEAM.—Formerly Stony Coal, and at Ford Common Lady Coal. Lies about 3 or 4 fathoms below the Three Quarter Coal.
USUAL SECTION.
Roof, bastard limestone.

	Ft.	In.
Top Coal, splinty	1	3
Macker, which will burn, but with large residium	0	9
Ground Coal	1	3
	3	3

This seam is very liable to undergo the process of "nip out" or "nither," sometimes to the disappearance of the seam for 250 yards—as to north of Shoreswood Pit.

The "conglomerate" freestone, which takes the place of the seam (see specimen), appears composed of rounded pebbles, broken vegetable remains, and even shells, the latter being often surrounded with a brilliant envelope of "iron pyrites," which substance it is not unfrequent in other instances of this formation to find attracted to, or forming the nucleus of, a group of vegetable or animal matter, once floating in the mud or sea prior to its undergoing the hardening influence of internal heat.

This forms the supply of the Shoreswood and Felkington Collieries, to the extent of about 21,000 tons annually.

It is admitted to be the seam of the district from which household coal of the richest and best quality is obtained, as well as most advantageously to the enterprizer.

Its appearance when wrought is large and square: is highly bituminous, and, although leaving, as all the coals of this series do, a white residium, still burning with a bright flame and lasting properties.

This seam is found in more or less perfection in all the collieries of the district, being most extensively exhausted at Shoreswood.

The so-described "Macker" increases in those to the north, as at Berwick Hill, from the thickness quoted in the general section up to 2 feet 6 inches and 3 feet, and in the collieries further south it somewhat diminishes.

It has not yet been sunk to at Scremerston New Pit, but is fully expected to be in good condition there, as it is at present being worked at Berwick Hill to its rise.

12.—WESTER COAL, lying about 10 fathoms below the Cooper Eye; and General Section as at Felkington New Pit. Roofstone, blue shale.

	Ft.	In.	Ft.	In.
Coal	....		2	2
Limestone Band	1	6	....	
Coal	....		0	7
Blue Shale Band	3	0	....	
Coal	....		0	10
	4	6	3	7

This is the lowest seam of the series, overlying a considerable mass of shale, and that resting on the red sandstone, and during the exhaustion of those of more profitable working, has not been extensively sought after.

It has lately been sunk through within the workings of the recently-commenced colliery of Felkington, and in former times had been wrought at some of the rise pits of Shoreswood, and more extensively at those collieries more immediately situated at, or nearer to, the outcrop of the series, such as Etal and Ford: won by extensively driven day-levels obtained from the rapidly-descending surface to their west.

It is almost needless to conclude these remarks on the different coal seams by adding that, notwithstanding, the antiquity of the working and partial exhaustion of the various beds, the gradually increasing powers of communication to more distant points of disposal will eventually introduce winnings on a more enlarged and expensive scale to accomplish the drainage of the various seams of coal and other minerals in their gradual dip to the east, and after the working out of the natural drainage afforded by day-levels; but this period will, of course, be guided in its event by the process of supply of the rest of the district, and this again influenced by the approach of railroad communication urging the tide northward of the coal-field proper of South Northumberland, and eastward of the districts being explored in Liddlesdale and elsewhere.

The mode of working adopted is universally the same throughout the district, and has been handed down from very ancient usage, viz., that of the long wall system. The explorations of "levels" at the dip side laying dry a certain panel or width of "wall face" at right angles to the said levels, and wide in proportion to the requirements of the daily "out-put," or of the powers of the perpendicular engine-lifts or day-drifts employed. This wall face is divided amongst the workmen to the extent of ten, twelve, or fifteen yards to each man, according to the thickness or hardness of the seam. The means used of transmitting the coals being generally by round tubs capable of being transferred from the framework or sledge on which it is placed, and drawn on the sliding and often moistened floor of the seam by one pony along and from the face to the "gateway" or "rolley-road," planned at convenient distances of 100, 120, and 150 yards apart, and there elevated to the economical and improved transit of rolleys drawn in sets of six, eight, or ten, as circumstances admit, by a pony or horse of greater power;—hauling engine power having been already introduced on the rolley-roads of the more advanced collieries, or where the employment of shafts or exits occur to the rise of the lowest drainage or water level.

It may readily be imagined that the very general existence of strong limestone bands in the sections of seams enumerated, and which, to a manager of "board and pillar" working, would be a marked and almost insurmountable difficulty, is here hailed as a powerful ally in forming the front edge, even with considerable intervals of the pillar behind (about four or four-and-a-half feet) the workmen around, between and behind which pillars the stouring or "gob" is effected, as best it can, by the other refuse or kirving material made and met with in the working.

Where these bands are absent or not strong enough wherewith to form pillars, then recourse is frequently had to a portion of the roofstone for the same, the last alternative being the employment of strong timbering not expected to be again drawn or used. I need scarcely add that the heaviest item in the cost of production is the correct pillaring and keeping open of the branch rolley-roads or "gateways" which necessarily are preserved as access to the face by well selected and neatly finished pillars. The requisite preserving of the height after the squeeze or crush occurs of the superincumbent strata, the effect of which to the eye of a stranger is a matter of surprise and curiosity, being effected by cuttings made in the altered floor or roof of the rolley road, as is found most convenient.

The moistening of the particles of iron pyrites stowed together with the rubbish is sufficient to alter its condition from the state of sulphuret to that of sulphate of iron, the decomposition of which frequently causes considerable increase of temperature, and the discharge of strong and stifling perfume, otherwise the ventilation under this system is not difficult to maintain, the extent of run or traverse of the air being in no case very great, and that portion by the face and water-levels easily accessible.

AS AN ITINERARY

To investigate the particulars already described, let the tourist commence at Tweedmouth, on the south side of the Tweed, and proceed southward, and he will find himself travelling on the ascent of the thick freestone underlying the coals and limestones, and so particularly described by Winch in his paper on the Red Sandstone of Berwickshire.—Natural History Society's Publication, vol. I., page 117. The new cemetery, and the extensive quarry behind it, show its enormous thickness, its unvarying characteristic of red colour and gritty hardness, and its outcrop to the north. (See Mr. Winch's section already quoted, and see also Major Johnson's section in the cut made for the Great North Road, and the details of which occur in my general section.) In this cutting is developed very clearly the resting of the shales and the lowest or Wester and Cooper Eye Coal Seams, and the lighter freestones, with their full rise here nearly due north, at a rate of not less than 1 in 6, on the aforenamed red sandstone. The latter seam (the Cooper Eye) occupies Berwick Hill Colliery, at a depth of forty fathoms from the surface; but explorings in it have recently been urged still farther to the dip. This coal is not here quite in as great perfection as at Shores-

wood, but supplies a large portion of the trade of Berwick and surrounding district. This seam is unwatered by means of a long level brought up from behind Spital.

Between the Cooper Eye Seam and the Bulman above it, the same road cutting passes through that strong and nearly white layer of sandstone, forming the remarkable escarpment afterwards named, on which Duddo Tower stands, and ranging south and west through Greenlawalls and Etal estates.

In travelling west from this point, the tourist for some distance continues nearly in a line parallel with the outcrop of strata. Having crossed the range of No. 1 Dyke (alluded to under that head), at the approach to the Etal and Berwick Turnpike near Etal and Billy Law, No. 2 Dyke is likewise passed (the first of the series of rise troubles); and here the Unthank Square and Old Engine Houses evidence the extensive colliery operations in former times, although not at present in action, in this neighbourhood.

On the Murton and Thornton estates are appearances of a similar nature, with remains of old shale heaps following each other so closely as to denote accurately the line of water level through these properties, even to the occurrence of a Dip or Rise Dyke—the next shaft sunk varying from the line hitherto preserved, either "out" or "in," according to whether the dyke is upcast or downcast in the direction taken. On the former of these estates, the frameworks of pumping engine houses evince that recourse was had to perpendicular pumping engine power for the drainage, and the greatest depth explored thereby was usually about forty fathoms, the seams wrought being the Scremerston Main Coal, Bulman, and Cooper Eye.

On entering Thornton, you pass the line of No. 3 Dyke, described in its place.

The ravine crossed by the turnpike at Unthank, Miller's Bridge, discovers the heavy feeders of water which continue to serve out of the old free water levels, by which the upper rise portion of the workings in the three seams mentioned were unwatered in Unthank, Shoreswood, and Felkington estates, and which feeders, but for the preservation of barriers, would have proved a serious burthen on the opening and working of the lower or dip workings.

Ascending the hill to Camp Houses and Allerdean, you come in sight of the present working at Shoreswood Colliery, here engaged in the finest sample of the Cooper Eye Seam, and supplying household coal to

that portion of West Berwickshire and part of the border county of Roxburghshire, which extend beyond the influence of the carboniferous range.

Nos. 4, 5, and 6 Slip Dykes are now passed, and are all downcasts to west and south (the range of old water level pits describing them). All occur within the next adjoining estate of Felkington, and nearly at its southernmost extremity, may be observed the first, and here the farthest north-west, working of limestone, in the Woodend Limestone (so called from having been extensively wrought at a place of that name), although the so-called Dunstone Limestone is below it, and is the first workable bed above the aforenamed coal seams. Their relative thickness may be quoted at seven feet the Dunstone, and fifteen feet the Woodend.

Near here, No. 7 Slip Dyke, and the Upright Basaltic Dyke, occur within a quarter of a mile of each other (see their description in their place). The towering situation of the remains of Duddo Tower, elevated on the headland here formed to the west and south by the Ten-Quarter Freestone, being a good landmark of the line of direction of this intrusion of igneous matter perpendicularly, and in a straight course through the carboniferous deposits. The fact of the basalt (of a dark blue colour) having been here extensively quarried for road material (at Mattilees and Duddo), affords a good opportunity of minutely observing its structure, width, and perpendicularity, and its burning effects on the adjacent strata, together with the peculiarity already noticed of its being shifted or altered in its course for a space greater than its own width, by the simultaneous side action of a "slip fault," observed here in the coal seam workings — a circumstance that is corroborated by a similar influence exerted on a Whin Dyke at Cockfield Fell.

Within this panel the Greenlawalls Colliery is wrought, the rise portions of the Main Coal and Cooper Eye Seams having furnished its supply for more than a century.

It is at this point that attention may be drawn to the basset of the Ten-Quarter Freestone, lying between the Cooper Eye and Main Coal or Bulman Seams, the ground, wherever it occurs, assuming a lofty and naked appearance, and frequently a bare escarpment, as it does here for nearly a mile in length, and particularly where suddenly terminated by No. 8 Dyke—the softer stratum of shale on its south side being worn away by external influences, leaving the freestone as a bold cliff of twenty-eight or thirty feet in thickness.

Throughout the continuance of the three estates of Greenlawalls,

Gatherick, and Longheugh (part of Etal), and prior to the occurrence of No. 8 Dyke, the seams of coal continue to range pretty regularly at a water level of S. 45 E., and the full rise about 1 in 7.

The effects of No. 8 Dyke is next remarkably apparent in descending from Gatherick Village to the ravine to its south. The two opposite high-topped, though rounded hills, bespeak sufficiently the disturbing influence of the One-Hundred-and-Nine and Seventy-Fathom Dykes, which has opposed the upreared edges of the strata to whatever subsequent denuding effects they have since been subjected; and all this suddenly terminated by the rapid descent of country towards the Till, as at Berry Hill, sufficiently abrupt to allow a water level day drift to be introduced on the hill side, and driven in the opposite direction to the sudden rise of strata, so as after a drifting of nearly one and a half mile, to unwater the coal seams at a point forty fathoms geologically deeper than where the said seam outcrops to the surface.

Between Nos. 8 and 9 Slip Dykes the observer may again have the opportunity of examining the appearances and influences of the Upright Whin or Basaltic Dyke, and satisfy himself that this limb, whose course is here N. 73 E., must be a fork from the Main Whin or Duddo Dyke, and must join or come in contact with the latter at or near the village of Bowsden—its extensive quarrying for road material, on the road from Bowsden to Ford, affording again the means of inspecting its effects on the adjoining strata, and its igneous and protruding characteristics. For reasons already stated, I have not ventured to draw its course much farther west, but have no doubt that, if it were desirable, it might be traced in the vicinity of Etal and Crookham Villages.

We now approach the farthest south-west edge of our plan and section, for after the influences of Nos. 8, 9, and 10 Slip Dykes—all downcasts to south—have tended to widen the breadth of our district at this point, by detaining the lower portions of the carboniferous strata longer within the surface, and the rough and jagged escarpments of the harder sills (the Ten-Quarter and other freestones) seem to have preserved the elevated and barren character of the Ford Common, before the descent to the richer land around Ford Castle. We find that the outcrop of the different strata at this point suddenly change their direction, varied, however, at certain intermediate positions, by the tortuous curvings observable in the different limestone quarries of ancient date at the back of Ford Common.

Between Nos. 12 and 13 Dykes the outcrop of this panel runs nearly

east and west, and by the regularity and fine development of the different limestone beds in the vicinity of the village of Lowick (worked chiefly by Mr. Steavenson of Lowick), as well by their rapid rise towards their outcrop here, present the most favourable deposit, within the shortest space, of this valuable mineral, no less a number than seven or eight different limestones being traceable within the space of one and a quarter mile, varying in thickness from eight to eighteen and twenty feet each, and embracing a total section of mountain limestone of between 130 and 140 feet. Almost without exception, each limestone is underlaid by a small seam of coal, but most of them at this point are too thin to be workable; and Mr. Steavenson and Mr. Salisbury derive their coal for lime burning principally from the Licker and the Rough Coal, the two little seams forming the highest of the series of the Lowick district adjoining the East and West Whin Dyke, but their near approach to exhaustion would seem to indicate the propriety of a railway being introduced into this part of the district shortly, in order to the delivery of a cheap coal for the more extensive opening out and disposal of that valuable fertilizer, the mountain limestone.

As my third line of section, from E to F, follows very nearly in the course of the last of the dykes (No. 14 or Hetton Dyke), I may conclude my remarks by a few observations in tracing its course to the high water mark at Fenham Flats.

I need scarcely remark that this is the most interesting of the sections, because it is nearly at right angles to the line of outcrop of the whole of strata included, and because it is the only one which crosses the lofty range formed by the Whin Sill.

In keeping with the other parts of the district, this partakes of the usual surface characteristics, viz., a cold, wet, and boggy surface where the coals and shales are prevalent, as at Biter Bit (or Biteabout) and Doddington, improved by the crossing of the limestones as substrata, as evidenced by the good Northumberland farms at Laverick Law, Holburn, and Hetton. This feature, again altered by the lofty rounded range of hills formed by the thick red sandstone of Heddon Hill and Cuthbert's Cave, on the surface of which, for the space of nearly a mile and a quarter in length, the "heather," "lichen," and "ling" reign supreme, the summit level having here reached nearly 590 feet above the level of the sea, and these again capped by the overhanging cliffs of the Dark Blue Whin Sill, which, though bare on their summits for want of soil covering, and nearly perpendicular on their western escarpment for two miles in

length, with an average height of 125 or 130 feet, evince the productive character of their debris, by the luxuriance of the growth of the fir trees studded around their base, and the rich character of grass land wherever affected by the material washed from their sides.

The scene at Boggle Houses may be described as the wildest in the entire district embraced, being in the nature of a ravine or "bight," enclosed to the north and east by the aforesaid escarpment of Whin Sill; to the west by the still higher outline of the sandstone hills of Heddon; and to the south and east by the deep woods of Detchant and Fenwick (see sketch), and presenting a sterile and gloomy picture, more like some of the dark glens of Scotland than any portion of Northumberland might be expected to contain.

I have had much difficulty in accounting for the appearance of a portion of this Whin Sill on the high ground near Buckton Farm House, and marked on the general plan, and can only accommodate its appearance there as being of the same "Sill" as the rest, by considering it a distinct fork or separate intruded layer or bed as a branch from the main body of the Whin—such an appearance being noticed by Mr. Hutton in his paper in "Natural History Society's Transactions," Vol. II., page 98, as at or near Hartington and Little Swinburne.

The two queries of importance in reference to this "Whin Sill," and to which I should very much like to have had opportunity of procuring replies, are—

First—Whether throughout the whole range of its appearance, from Kyloe to Cumberland, it is always invariably overlaid and underlaid by the same strata, or geologically occupies the same position relative to the district in which it occurs?

And secondly—Whether the perpendicular Basaltic Dyke to the north of Kyloe penetrated through and severed the "Whin Sill," as it did the other strata, or whether their protrusion was coeval, and that they amalgamated together in the fused state?

From this lofty position, down to the sea-side at Fenham, the observations have already been recorded, under the head of "Enumeration of Strata," and, as there stated, by reason of the thick alluvial soil covering the substrata, and the paucity of borings and sinkings, quarries or ravines, the data whereon to found geological deductions, are much more difficult to acquire.

The appearance of two limestones, with their full rise to the south-west, in Holy Island, and the Basaltic Dyke, chosen as fit foundations

ceedings No. of E. I. of M.E. 1860 I.)

LOOKIN

Drawn on Stone & Lithographed by And^r Reid, Newcastle upon Tyne.

Proceedings N^s of E. Inst M.E. 1860 I.

SKETCH FROM HOLBURN WOOD HOUSES, LOOKING NORTH, WITH HOLY ISLAND & FERN ISLANDS IN THE DISTANCE.

Proceedings N° of E. I of M.E. 1860-1.

OF CONTO

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Drawn on Stone & Lithographed by Andw Reid, Newcastle upon Tyne.

Proceedings No. of E. I. of M.E. 1860 I.

SKETCH OF CONTORTED STRATA OF LIMESTONE,

(BEING THE EELWELL LIMESTONE)

ON THE SEA COAST NEAR SCREMERSTON, LOOKING SOUTH

for the Castle there, sufficiently attest its connection and relative position with the main land. The mouldering nature of the freestone, of which the ancient Holy Abbey has been constructed, also showing the necessity of care in the selection of material proposed to be used for so enduring a purpose.

I do not propose describing the outline of strata northward from this point along the coast lines, however beautiful and instructive it may be, because it has already formed the subject of a very interesting paper for the same purpose, by Mr. Nicholas Wood, in the 2nd Vol. of "The Transactions of the Natural History Society."

But I may conclude by referring to that paper as amply corroborative of the sectional detail I have ventured to introduce into this paper.

I may be allowed to use this opportunity of expressing my obligation and sincere thanks to Mr. George Bailes, of Allerdean, agent to the Scremertson, Shoreswood, and other Collieries, for the able and ready assistance with which he has furthered my enquiry, by aiding in the sections and general exploration of the district; and to Mr. Steavenson, of Lowick Lime Works, and Mrs. Johnson, of Scremerston, for the sections of lime and coal strata more immediately connected with the localities in which they are interested.

DETAILED ACCOUNTS OF STRATA PASSED THROUGH IN VARIOUS INDIVIDUAL SINKINGS IN THE DISTRICT.

No. 1.

Section of Strata sunk through to the Main Coal Seam in the Jack Tar Pit, Scremerston Colliery.

No.		Fms.	Ft.	In.	Fms.	Ft.	In.
1	Soil	0	1	0			
2	Clay	0	3	0			
3	Soft brown freestone	0	3	10			
4	Blue metal	1	4	8			
5	Limestone (Woodend)	1	1	0			
6	Blue metal	2	2	0			
7	*Coal*	0	0	6			
8	White metal	1	2	0			
9	White freestone	0	4	0			
10	Blue metal	0	1	6			
11	*Coal*	0	0	6			
12	White freestone bands	1	1	0			
13	Tills	0	4	6			
14	Freestone bands	0	2	0			
15	*Coal* (*Biteabout seam*)	0	1	8			
					11	3	2
16	White freestone	1	1	4			
17	Blue metal, mixed with freestone bands	0	5	1			
18	*Coal*	0	0	2			
19	Soft Grey freestone	0	3	3			
20	Freestone bands	3	2	4			
21	Hard tills	3	3	0			
22	Limestone (dun)	1	1	0			
23	*Coal*—Found generally below dun stone throughout the district	0	1	2			
					10	5	4
24	Grey metal	0	4	4			
25	Hard freestone	1	2	2			
26	Grey metal	0	3	0			
27	Freestone mixed with tills	5	5	0			
28	Soft white freestone.—Quarry in it on sea-coast	13	5	6			
29	*Coal* (*Robic's coal*)	0	1	5			
					22	3	5
30	Black metal, mixed with freestone bands	3	0	0			
31	Light blue metal	2	0	9			
32	Hard blue metal	2	3	10			
33	Hard white freestone beds.—Richardson Stead Quarry in these	3	0	0			
34	Blue metal	1	0	0			
35	Bastard blue metal	1	1	2			
36	*Coal* (*Caldside seam.*)—Nearly nipped out here over an extent of 300 yards east and west, and from outcrop to dip	0	0	8			
					13	0	5
37	Dark brown metal	0	1	4			
38	Hard freestone	0	0	11			
39	Blue metal	0	1	9			
40	Hard white freestone	0	3	0			
41	Blue metal	0	1	6			
42	Hard white freestone band	0	0	8			
43	Blue metal	0	5	6			
44	*Coal*	0	0	3			
					2	2	11
	Carried forward				60	3	3

No.		Fms.	Ft.	In.	Fms	Ft.	In.
	Brought forward				60	3	3
45	Soft light blue metal	1	4	2			
46	Hard freestone band	0	0	5			
47	Soft light blue metal	0	0	7			
48	Hard brown stone	0	2	2			
49	Hard blue metal	0	2	3			
50	Soft blue metal	0	2	1			
51	Hard flinty girdles	0	1	9			
52	Soft light blue metal	0	3	1			
53	Dark blue metal	1	3	1			
54	Soft blue metal	0	1	9			
55	Red freestone	2	2	7			
56	Soft blue metal	0	0	11			
57	*Coal*	0	0	2			
58	Dark grey whin	0	0	3½			
59	Soft blue metal	2	1	8			
60	Soft light blue metal	2	2	1½			
61	Limestone	0	1	2			
62	*Coal* (*splinty*)	0	0	4			
63	Soft light blue metal	0	4	11			
64	Hard white freestone	0	3	8			
65	Soft blue metal	1	0	0			
66	Dark grey freestone	1	2	1			
67	Hard dark blue metal	3	2	8			
68	*Coal*	0	0	1			
69	Black metal	0	0	2½			
70	Hard grey freestone	1	1	8			
71	Dark blue metal	1	2	9			
72	*Coal*	0	0	6			
73	Dark blue metal, ironstone band ½ inch ..	0	2	0½			
74	*Coal*	0	0	8			
75	Black dant	0	0	3			
76	*Coal*	0	0	11½			
					23	5	0½
77	Brown metal	0	0	8½			
78	*Coal*	0	1	1			
79	Soft dark blue metal	0	1	2			
80	*Coal*	0	0	2			
					0	3	1½
81	Soft dark blue metal	0	0	7			
82	Hard white freestone	1	0	5			
83	Soft dark blue metal	0	1	3			
84	Hard grey freestone	0	3	6			
85	Dark blue metal	0	4	10			
86	*Coal* (*splinty*)	0	0	3			
87	Hard tills and metal	1	1	4			
88	*Coal*	0	0	2½			
89	Hard dark blue metal	0	2	4			
90	*Coal*	0	0	4			
91	Dark blue metal	0	0	6			
92	*Coal*	0	0	5			
93	Hard tills	0	5	4			
94	Limestone	0	0	6			
95	Soft blue metal	0	2	2			
96	Hard freestone	0	0	5			
97	Soft blue metal	0	0	9			
98	Hard white freestone	1	4	3			
99	Blue metal	0	1	2			
100	Hard white freestone	0	3	3			
101	Dark blue metal	0	5	2			
	Carried forward	9	2	11½	84	5	5

No.			Fms.	Ft.	In.	Fms.	Ft.	In.
	Brought forward ..		9	2	11½	84	5	5
102	*Coal*		0	0	6			
103	Blue metal		0	0	4			
104	*Coal*		0	0	7			
105	Soft dark metal		0	0	9			
106	Hard white freestone		0	3	6			
107	Dark blue metal		0	1	5			
108	*Coal*		0	0	7			
109	Soft light blue metal		0	1	7			
110	Hard grey freestone		0	3	3			
111	Dark blue metal		0	1	2			
112	*Coal*		0	0	4			
113	Dark blue metal		1	2	5			
114	Red freestone		1	5	5			
115	White freestone		0	0	7			
116	Soft dark blue metal		0	3	1			
117	*Coal*		0	0	10			
118	Soft dark blue metal		0	1	1			
119	*Coal*		0	0	5½			
						16	0	10
120	Dark blue metal		0	4	8			
121	Dark red freestone		4	0	4			
122	Light grey whin		0	1	0			
123	Dark brown limestone		0	0	8			
124	Tills and metal		0	3	11			
125	*Coal*		0	0	2			
126	Blue metal and dun post		0	2	10			
127	*Coal*		0	0	3			
128	Soft blue metal		0	0	2			
129	*Coal*		0	0	3			
130	Hard dun metal		0	3	8			
131	*Coal* and 1 inch of metal		0	1	0			
						7	0	11
132	Soft blue metal		1	1	0			
133	Hard freestone girdle		0	0	4			
134	*Coal (coarse)*		0	0	7			
135	Limestone—Roof of seam		0	1	2			
136	*Top coal* .. } *Scremerston* {	2 10						
	Grey stone band .. } *main coal* {	0 3						
	Ground coal .. {	1 3						
			0	4	4			
137	Blue metal thill		0	4	2			
						2	5	7
						111	0	9

No. 2.

Section of Strata sunk through to the Cooper Eye Seam at Shoreswood Colliery.

No.		Fms.	Ft.	In.	Fms.	Ft.	In.
1	Soil	0	0	3			
2	Soft white freestone	10	3	3			
3	White freestone	7	4	0			
4	Soft tills	1	1	6			
5	White freestone	0	2	6			
6	Dark blue metal	2	2	3			
7	*Coal*	0	0	8			
8	Grey stone—Roof of seam	0	0	8			
	Carried forward	22	3	1			

No.						Fms.	Ft.	In.	Fms.	Ft	In.
	Brought forward					22	3	1			
9	*Top coal*	*Main coal or Bulman seam.*	1	4							
	Chalk stone ..		0	1							
	Splint coal ..		1	10							
	Grey stone band ..		1	4							
	Ground coal ..		0	8							
	Chalk stone ..		0	1							
	Smithy coal ..		0	11							
						1	0	3			
									23	3	4
10	Blue metal thill					0	1	0			
11	Hard tills					0	2	2			
12	Soft tills					0	1	4			
13	*Coal*					0	1	2			
14	Limestone					0	1	3			
15	*Coal*					0	0	11			
									1	1	10
16	Blue metal					0	3	11			
17	*Coal*					0	0	11			
18	Grey stone					0	1	2			
19	Blue metal					1	2	0			
20	Limestone					0	2	10			
21	*Coal*					0	0	9			
22	Blue metal					0	2	4			
23	Grey stone					0	0	8			
24	*Coal*		0	10							
25	Grey stone		0	8							
26	*Coal*		1	4							
						0	3	0			
									3	5	5
27	Metal					0	5	8			
28	Freestone					1	2	1			
29	Dark blue metal					0	4	0			
30	Soft white freestone					0	2	1½			
31	Dark grey freestone					0	4	9			
32	Dark blue metal..					0	1	0			
33	*Coal*					0	0	5			
34	Dark blue metal..					0	1	10			
35	Limestone					0	0	5			
36	Hard grey freestone					1	3	1			
37	Dark blue metal					2	0	0			
38	White freestone					0	3	9			
39	Soft Tills					0	1	0			
40	Hard white freestone					0	3	0			
41	Light blue metal					1	2	2			
42	Limestone					0	1	11			
43	*Coal*					0	1	0			
44	Soft grey stone					0	0	4			
45	*Coal*					0	0	8			
46	Metal					0	0	5			
47	Grey stone					0	2	1			
48	*Coal (Three-quarter seam)*					0	2	1			
									12	1	9½
49	Black metal					0	3	1			
50	Brown limestone					0	1	4			
51	Metal and *Coal*					0	4	1			
52	Limestone—Roof of seam					0	1	0			
53	*Top coal* ..	*Cooper Eye Seam*	1	4							
54	Grey stone band ..		0	9							
55	*Ground coal* ..		1	2½							
						0	3	3½			
									2	0	9½
	Carried forward								43	1	2

No.				Fms.	Ft.	In.	Fms.	Ft.	In.
	Brought forward ..						43	1	2
56	Soft blue metal thill			0	3	2			
							0	3	2
	Total						43	4	4

No. 3.

Section of Strata sunk through in Felkington New Pit, and in a Staple from the Cooper Eye Seam on the Fourteen-Fathom Upcast Dyke south-west, to the Wester Coal Seam.

No.					Fms.	Ft.	In.	Fms.	Ft.	In.
1	Soil and clay				1	3	0			
2	Freestone bands				0	5	0			
3	Red sandstone				6	0	0			
4	Blue metal				0	2	5			
5	*Coal*				0	0	9			
6	Hard bastard limestone				0	2	6			
7	*Coal*				0	1	0			
8	Blue metal				0	2	10			
9	Limestone				0	2	7			
10	Blue metal				0	2	10			
11	*Top coal* ..	*Scremerston main coal, or Black Hill seam*		2	6					
12	Band stone ..			0	2					
13	*Ground coal*			0	10					
					0	3	6			
								11	2	5
14	Soft blue metal				0	2	0			
15	Limestone				0	0	3			
16	Strong grey tills				0	2	0			
17	Freestone				0	1	8			
18	Metal				0	0	2			
19	*Coal*	*Hardy, or stony coal seam*		0	9					
20	Band, blue metal			0	9					
21	*Coal*			1	2					
22	Band, limestone ..			1	2					
23	*Coal*			0	9					
					0	4	7			
								1	4	8
24	Strong tills, mixed with freestone				0	1	2			
25	Grey tills				0	1	0			
26	*Coal*				0	1	4			
27	Tills				0	2	0			
28	Freestone bands				0	4	0			
29	Limestone				0	1	6			
30	*Coal*				0	0	4			
31	Tills				0	2	6			
32	Blue metal				2	5	0			
33	Freestone bands				1	0	3			
34	Blue metal				1	4	0			
35	*Coal*				0	0	3			
36	Freestone bands				0	1	0			
37	*Top coal* ..	*Main coal or Bulman seam*		1	2					
38	Chalk stone ..			0	1					
39	*Splint coal* ..			1	1					
40	*Rough coal* ..			0	7					
41	Band, grey metal			1	8					
42	*Parrot coal* ..			0	8					
43	*Ground coal, parrot*			0	11					
44	Chalk stone ..			0	1					
45	*Smithy coal* ..			0	4					
					1	0	7			
								9	0	11
	Carried forward							22	2	0

No.				Fms.	Ft.	In.	Fms.	Ft.	In.
	Brought forward						22	2	0
46	Strong grey tills			0	0	7			
47	Soft light blue metal			0	0	9			
48	Freestone band			0	0	6			
49	Metal			0	0	3			
50	Limestone			0	1	1			
51	Black metal			0	0	10			
52	Limestone			0	0	3			
53	*Coal*			0	0	11			
54	Limestone			0	0	11			
55	*Coal*			0	0	7			
56	Strong tills			0	4	6			
57	Soft blue metal			0	1	11			
58	Tills			0	2	6			
59	Strong grey tills			3	0	0			
60	Freestone bands			6	2	0			
61	Blue metal			0	5	0			
62	Grey freestone			1	2	0			
63	*Coal*			0	0	6			
64	Hard red freestone, Ten-Quarter stone ..			3	0	0			
65	Blue metal			0	2	0			
66	Grey freestone, Ten-Quarter stone			2	3	0			
67	Blue metal			2	0	0			
68	Limestone			0	2	0			
69	*Coal*			0	1	0			
70	Metal			0	0	6			
71	Grey tills			0	2	0			
72	*Coal* ..	*Three-Quarter coal*	1	2					
73	Band stone ..		0	6					
74	*Coal* ..		1	0					
				0	2	8			
							23	2	3
75	Metal			0	3	0			
76	*Coal*			0	0	3			
77	Blue metal			0	1	6			
78	Freestone			0	2	6			
79	Blue metal			0	2	0			
80	*Coal*			0	0	3			
81	Limestone			0	1	2			
82	*Splint coal* ..	*Cooper Eye seam*	1	3					
83	Band stone ..		0	9					
84	*Ground coal* ..		1	4					
				0	3	4			
							2	2	0
85	Soft blue metal			0	3	0			
86	Limestone			0	1	6			
87	Tills			0	2	0			
88	Hard bastard limestone			0	3	0			
89	Blue tills			0	5	0			
90	Limestone			0	1	0			
91	Blue tills			0	1	6			
92	Freestone			0	2	0			
93	Blue tills			0	3	6			
94	Freestone			0	1	0			
95	*Coal*			0	0	6			
96	Metal			0	1	0			
97	Grey freestone			0	2	9			
98	Red freestone			0	2	9			
99	Limestone			0	1	4			
100	Metal			0	1	6			
	Carried forward ..			5	3	4	48	0	3

No.				Fms.	Ft.	In.	Fms.	Ft.	In.
	Brought forward			5	3	4	48	0	3
101	Limestone			0	1	8			
102	Freestone band			0	2	0			
103	Tills			1	0	0			
104	Limestone			0	2	6			
105	Metal			0	1	4			
106	Limestone			0	1	0			
107	Metal			0	2	6			
108	*Coal*	*Wester coal seam*	2	2					
109	Limestone ..		1	6					
110	*Coal*		0	7					
111	Blue metal band		3	0					
112	*Coal*		0	10					
				1	2	1			
							9	4	5
	Total						57	4	8

No. 4.

Section of Strata from the Thill of the Scremerston Main Coal to the Bulman, Cooper Eye, and Wester Coal Seams, at Scremerston and Berwick Hill Colliery.

No.				Fms.	Ft.	In.	Fms.	Ft.	In.
1	Blue metal			1	5	5			
2	Freestone			0	0	5			
3	Blue metal			0	3	4			
4	Freestone			0	0	6			
5	Blue metal			0	0	3			
6	Freestone			0	0	11			
7	*Coal*	Stony or hardy seam.				..	0	2	3
8	Band ..					..	0	0	6
9	*Coal*					..	0	0	10
							3	2	5
10	Blue metal thill			0	1	6			
11	Freestone			0	0	4			
12	Metal			0	0	1			
13	Freestone			0	0	5			
14	Brown metal			0	2	9			
15	*Coal*			0	0	5			
16	Brown metal			0	1	5			
17	*Coal*			0	0	7			
18	Brown metal			0	1	9			
19	White freestone			1	1	0			
20	Red freestone			1	1	0			
21	White freestone			11	0	5			
22	Parting			0	0	3			
23	White freestone			0	1	0			
24	*Coal*—Bulman seam here reduced to 2 feet, but is 4 feet thick at Berwick Hill ..			0	2	0			
							15	2	11
25	Blue metal			0	2	0			
26	Limestone			0	1	9			
27	Grey metal			0	1	0			
28	Limestone			0	1	0			
29	Metal			0	3	0			
30	Freestone			2	4	0			
31	Freestone (slaty)			0	3	0			
	Carried forward ..			4	3	9	18	5	4

No.		Fms.	Ft.	In.	Fms.	Ft.	In.
	Brought forward	4	3	9	18	5	4
32	*Coal*	0	0	6			
33	Tills	0	0	9			
34	Freestone band	0	1	0			
35	Grey metal	0	1	9			
36	Freestone (slaty)	0	4	0			
37	*Coal*	0	0	6			
38	Freestone	0	1	10			
39	Tills	0	0	4			
40	Freestone (slaty)	0	3	0			
41	*Coal*	0	0	6			
42	Freestone	0	1	10			
43	Tills	0	0	4			
44	*Coal*	0	0	7			
45	Grey metal	0	0	7			
46	Black tills	0	0	6			
47	Grey metal	0	3	0			
48	*Coal*	0	0	3			
49	Limestone	0	0	6			
50	*Coal*	0	0	5			
51	Blue metal	0	2	2			
52	*Coal*	0	0	7			
53	Freestone	2	0	6			
54	Metal	0	5	0			
55	*Coal*	0	0	7			
56	Blue metal	0	2	2			
57	Freestone .. } Ten-Quarter { ..	2	1	9			
58	Freestone .. } freestone. { ..	3	0	0			
59	Metal	0	4	0			
60	*Coal*—Three-Quarter	0	2	0			
					18	2	8
61	Limestone	0	0	3			
62	Freestone	0	3	5			
63	Metal	0	4	3			
64	*Coal*	0	0	2			
65	Metal	0	3	0			
66	*Coal*	0	0	3			
67	Blue metal	0	2	0			
68	Grey metal	0	2	0			
69	Limestone	0	1	6			
70	*Coal* (splint) .. } Cooper Eye {	0	1	3			
71	Grey freestone slate .. } coal. {	0	4	6			
72	*Coal* (ground) .. } {	0	1	4			
					3	5	11
73	Blue metal	0	4	0			
74	Limestone	0	1	6			
75	Blue metal	0	2	3			
76	*Coal*	0	0	8			
77	Limestone	0	2	6			
78	Grey metal	0	1	0			
79	Blue metal	0	2	8			
80	Freestone band	0	1	6			
81	Blue metal	0	5	4			
82	Blue metal	0	2	0			
83	*Coal*	0	0	3			
84	Grey metal	0	3	0			
85	Limestone	0	2	0			
86	Blue metal	0	1	0			
87	Freestone band	0	2	0			
88	*Coal*	0	0	9			
89	Freestone band	0	4	0			
	Carried forward	6	0	5	41	1	11

No.			Fms.	Ft.	In.	Fms.	Ft.	In.
	Brought forward ..		6	0	5	41	1	11
90	Grey metal		0	4	0			
91	Metal		0	0	10			
92	*Coal*		0	0	6			
93	Slaty band		0	4	0			
94	Blue metal		0	0	4			
95	Grey metal		0	0	4			
96	Blue metal		0	0	4			
97	*Coal*		0	0	6			
98	Limestone		0	0	4			
99	Blue metal		0	0	3			
100	Black metal		0	0	3			
101	Grey metal		0	4	2			
102	Freestone		0	6	0			
103	Grey metal		0	0	8			
104	Limestone		0	0	6			
105	Metal		0	1	4			
106	*Coal*		0	0	3			
107	Freestone		0	2	4			
108	*Coal*		0	0	4			
109	Blue metal		0	3	1			
110	Limestone		0	1	6			
111	Grey metal		0	0	6			
112	*Coal* .. .. Wester ..		0	0	6			
113	Blue metal .. coal ..		0	1	6			
114	*Coal* .. .. seam. ..		0	0	7			
115	Grey metal		0	0	8			
116	*Coal*		0	0	3			
117	Black metal		0	0	8			
118	*Coal*		0	0	6			
119	Black metal		0	0	6			
120	*Coal*		0	0	6			
						12	2	5
121	Blue metal		1	4	0			
122	Slaty stone		0	3	0			
123	Limestone		0	1	6			
124	Blue tills		0	0	10			
125	*Coal*		0	0	6			
						2	3	10
	Total depth					56	2	2

No. 5.

Section of Strata sunk through to the Cooper Eye Seam, Greenlawalls Colliery.

			Fms.	Ft.	In.	Fms.	Ft.	In.
1	Red gravelly clay		1	0	0			
2	Blue metal		0	5	0			
3	*Coal* .. }		0	1	2			
4	Limestone .. } *Hardy, or stony coal*		0	0	10			
5	*Coal* .. }		0	0	6			
						2	1	6
6	Grey tills		0	1	3			
7	*Coal*		0	1	1			
8	Blue Tills		0	6	7			
9	Freestone		0	0	10			
10	*Coal*		0	1	1			
11	Light blue metal		0	3	6			
	Carried forward ..		1	2	4	2	1	6

No.			Fms.	Ft.	In.	Fms.	Ft.	In.
	Brought forward		1	2	4	2	1	6
12	Grey freestone		0	1	3			
13	Blue metal		0	0	4½			
14	*Coal*		0	0	4½			
15	Grey metal		0	4	3			
16	Grey freestone		12	2	0			
17	*Top coal*	*Bulman or main coal* ..	0	1	3			
18	Hard brown metal ..		0	2	5			
19	*Good coal, splinty* ..	..	0	1	0			
20	Grey metal, with limestone		0	1	3			
21	*Coal, mixed with dant* ..		0	1	0			
						15	5	6
22	Grey freestone		0	0	3			
23	Black metal		0	0	3			
24	*Coal*		0	0	3			
25	Dark brown metal		0	1	3			
26	*Coal*		0	0	3			
27	Limestone, very dun		0	1	4			
28	*Good coal*		0	0	3			
29	Blue metal		0	2	6			
30	Limestone, with freestone		0	0	7			
31	*Coal, with black dant*		0	0	9			
32	Limestone		0	0	5			
33	Blue metal		0	0	9			
34	*Coal, mixed with dant*		0	0	10			
35	Brown freestone		0	1	0			
36	Grey do.		0	0	10			
37	Blue metal		0	0	9			
38	Grey freestone		0	1	1			
39	Black metal		0	2	0			
40	Grey freestone		0	2	5			
41	White do.		0	1	7			
42	Grey do.		0	3	9			
43	*Coal*		0	0	2			
44	Grey freestone		0	5	3			
45	*Coal, mixed with metal*		0	0	8			
46	Hard grey freestone		0	4	9			
47	Blue metal		0	0	3			
48	Hard white freestone		0	1	7			
49	White metal		0	2	5			
50	Hard white freestone		0	0	5			
51	Blue metal		0	0	2			
52	Freestone		0	2	10			
53	White metal		0	0	4			
54	Hard white freestone		0	1	11			
55	Blue metal		0	0	2			
56	White freestone		2	0	0			
57	Blue metal		0	2	5			
58	Limestone		0	2	5			
59	*Coal*		0	0	6			
60	Blue metal		0	2	7			
61	Grey freestone band		0	0	4			
62	*Three-quarter coal*		0	2	3			
						11	0	6
63	Blue metal		1	1	2			
64	Grey freestone band		0	0	9			
65	Grey tills		0	1	9			
66	Limestone		0	1	1			
67	*Cooper Eye coal*		0	2	3			
						2	1	0
	Total					31	2	6

No. 6.

Section of Strata sunk through to the Bulman or Main Coal Seam at Gatherick Colliery, 15th September, 1819.

No.			Fms.	Ft.	In.	Fms.	Ft.	In.
1	Soil and clay		1	3	0			
2	Freestone bands		2	5	0			
3	White freestone		2	5	0			
4	Grey do.		4	4	6			
5	*Coal (rough)* ..	*Blackhill or Scremerston main coal seam.*	0	1	5			
6	Bastard limestone ..		0	0	8			
7	*Coal*		0	0	6			
8	Blue tills		0	2	0			
9	*Coal*		0	1	2			
						12	5	3
10	Freestone		0	2	4			
11	*Coal (coarse)*		0	1	4			
12	Freestone band		1	3	0			
13	*Coal (slaty)*		0	0	5			
14	Black tills		0	1	4			
15	Limestone		0	1	0			
16	Blue tills		1	3	0			
17	Hard freestone		0	3	5			
18	Tills (strong)		0	2	6			
19	Freestone		0	2	0			
20	Tills		0	3	0			
21	Metal (soft and white, like marl)		0	3	6			
22	Tills, mixed with tender freestone bands		0	2	0			
23	*Top coal, generally left on* ..	*Bulman or main coal.*	0	1	0			
24	Chalk stone ..		0	0	1			
25	*Splint coal (strong)* ..		0	1	4			
26	Blue metal		0	0	4			
27	*Splint coal*		0	1	0			
28	Chalk stone		0	0	1			
29	*Smithy coal*		0	0	7			
						7	3	3
30	Soft metal					0	0	10
	Total					20	3	4

No. 7.

Section of Strata sunk through to the Hardy Coal, Main Coal, Three-Quarter Coal, and Cooper Eye Coal Seams, at Gatherick Colliery, 1819.

No.			Fms.	Ft.	In.	Fms.	Ft.	In.
1	Soil and clay		1	3	0			
2	Freestone bands		2	5	0			
3	White freestone		2	5	0			
4	Grey freestone		4	4	6			
5	*Coal* (rough) ..	Hardy or stony coal seam	0	1	5			
6	Bastard limestone ..		0	0	8			
7	*Coal* (good)		0	0	6			
						12	2	1
8	Blue tills		0	2	0			
9	*Coal* (splinty) ..	Diamond seam	0	1	2			
10	Freestone band ..		0	2	4			
11	*Coal* (coarse) ..		0	1	4			
						1	0	10
	Carried forward					13	2	11

No.				Fms.	Ft.	In.	Fms.	Ft.	In.
	Brought forward						13	2	11
12	Freestone band			1	3	0			
13	*Coal* (slaty)			0	0	5			
14	Black tills			0	1	4			
15	Limestone			0	1	0			
16	Blue tills			1	3	0			
17	Freestone			0	3	5			
18	Tills (very strong)			0	2	6			
19	Freestone			0	2	0			
20	Tills			0	3	0			
21	Metal			0	3	6			
22	Tills			0	2	0			
23	Top *coal* ..	Main or Bulman coal seam	..	0	1	0			
24	Chalkstone ..		..	0	0	1			
25	Splint *coal* ..		..	0	1	4			
26	Blue metal band ..		..	0	0	4			
27	Splint *coal* ..		..	0	1	0			
28	Chalkstone ..		..	0	0	1			
29	Smithy *coal* ..		..	0	0	7			
							6	5	7
30	Soft blue metal			0	0	10			
31	Strong white tills			0	4	0			
32	Black metal			0	3	8			
33	Limestone			0	2	0			
34	Black metal			0	2	0			
35	*Coal*			0	0	8			
36	Freestone band			0	0	3			
37	*Coal*			0	0	6			
38	Tills			0	4	5			
39	Freestones bands			0	2	6			
40	*Coal*			0	0	5			
41	Dark blue metal			0	5	0			
42	Light grey metal			1	3	10			
43	Dark grey metal			1	2	8			
44	Dark grey freestone			2	5	8			
45	Black metal			0	2	3			
56	Limestone			0	2	8			
47	*Coal*			0	0	2			
48	Black metal			0	4	6			
49	*Coal*	Three Quarter Coal	..	0	0	10			
50	Brassy band ..		..	0	0	3			
51	*Coal*		..	0	0	7			
							12	1	8
52	Dark grey metal			0	3	6			
53	Hard brown limestone			0	1	3			
54	Dark blue metal			0	3	8			
55	Limestone roof			0	1	2			
56	Cooper Eye *coal*			0	2	2			
57	Thill			0	0	5			
							2	0	2
	Total depth						34	4	4

NORTH OF ENGLAND INSTITUTE
OF
MINING ENGINEERS.

GENERAL MEETING, THURSDAY, JUNE 6, 1861, IN THE ROOMS OF THE INSTITUTE, WESTGATE STREET, NEWCASTLE-UPON-TYNE.

NICHOLAS WOOD, ESQ., PRESIDENT OF THE INSTITUTE, IN THE CHAIR.

The SECRETARY having read the minutes of the proceedings of the Council,

The following gentlemen were elected members of the Institute:—Mr. John Fletcher, of Clifton Colliery, Manchester, and Mr. Wm. Blow Collis, The Platts, Stourbridge, Worcestershire.

Several gentlemen were then proposed for election, after which,

The PRESIDENT said, the first thing upon the minutes was the circular from the Council calling upon members to communicate either by letter to the Secretary on or before Thursday, the 6th of June, or personally at that meeting, their intention to visit Birmingham on the occasion of the approaching gathering of engineers. They had got a list of several gentlemen who proposed to attend the meeting, but he was sorry to find there were not more members of the Institute from this district; he hoped, however, before the time arrived, they should have a longer list. There was a considerable list of members at a distance, and from what he had heard, he hoped they should have a considerable number of outlying members at that meeting. The meeting seemed to be rather popular in the Midland Counties, and he fancied they should have plenty of work to do.

Mr. POTTER hoped the people from this part of the district would countenance the scheme.

The PRESIDENT went on to say, the next subject was that he (the President) should endeavour to procure a meeting in London with

some members of the Local Committee, to discuss the particulars of the July meeting. In accordance with that request, he had summoned a meeting on Monday last, in London, which was attended by those gentlemen who were in town, and some from the Midland Counties, who came up to town to that meeting. The matter was fully discussed, and it was arranged that there should be a meeting of the Local Committee in Birmingham on Monday next. It was considered desirable that one or two members from Newcastle should attend that meeting, with a view of coöperating with the Local Committee, and making the best arrangements for promoting the object in view. The committee seemed very much inclined to advise that persons, not members of the Institute, might send papers through the members to be read at the meeting. Of course, he could give no opinion on that individually, but he said he thought it would be a proper subject for the Local Committee to discuss at the meeting on Monday next; and as the Institute would have a general meeting on the 4th of July, before the meeting in Birmingham, they could then decide on what they thought most desirable, more especially as by that time they should have a list of all the papers proposed to be read, and might select such papers as they thought desirable to be read. Mr. Blackwell had erected, he believed, one of the largest air-pumping machines yet in use; it was partially at work, and Mr. Blackwell promised to give them plans of that machine. Mr. Woodhouse would give them a paper on the system of working "long wall" in Derbyshire and Nottinghamshire; and Mr. Blackwell would give them a paper on the mode of working the Thick Seam in Staffordshire. Unfortunately, the meeting came off in the week when the ironmasters met at Birmingham, and it appeared to be questionable if the meeting of the Institute could be held the same week. The Local Committee would, however, take that into consideration, and submit their opinion to the Council of the Institute. The committee seemed to think that it would be very desirable that the meetings should be open to all the managers of mines of every description; and they thought that the inferior managers might obtain useful information in the discussions that might take place. Individually, he thought it very desirable that their arrangements should be such as would admit the inferior as well as the higher grades of managers of mines, so as to make the meetings as useful as they could.

Mr. Matthias Dunn supposed reporters would be admitted?

The President supposed so. They had not, however, arranged about that. The Institute must have a reporter there to take notes for them.

He did not himself see any objection to reporters generally being there. It was not like a private meeting of the Institute, but was more of a public nature. He supposed the Local Committee would make some recommendation on the point, and then they would finally determine on the 4th of July what was to be done. The next proposition was the issuing of a circular, to be addressed to the Inspectors of Mines throughout the kingdom, directing their attention to the proposed meeting and soliciting their support. In that circular the inspectors were asked to communicate with the members of any local mining associations in their several districts, and to ask if they wished to be present and to take part in the proceedings, and if so, that tickets would be at their service.

After some further conversation with reference to the Birmingham meeting,

The PRESIDENT went on to say, the members would recollect that at the last meeting he mentioned to them a decision of the Council, which was confirmed by the general meeting, that a memorial should be presented to the Government, to ask them to allow the Institute to give evidence before the Commission which was proposed to be issued to inquire into the University of Durham. That memorial he had sent to Sir George Lewis, Bart., and after some short time he had a letter from that gentleman acknowledging the receipt of the memorial. He likewise sent copies of the memorial to the Bishop of Durham, Lord Granville, and some other gentlemen, whom he knew took great interest in promoting the views of the Institute in the formation of a Mining College, and he had from all of them letters acknowledging the receipt thereof, and expressing their readiness to do everything in their power to aid the views of the Institute. He had seen in the paper of that morning that the subject had been brought before the Town Council of Newcastle at their meeting on the previous day. He saw that Dr. Headlam stated that a commission was likely to be issued to inquire into the state of the University of Durham, and that he believed certain members of the commission had been appointed. Dr. Headlam went on to say, it was very important the University should be placed on a sound and comprehensive basis, and he gave notice to move that the Council should recommend certain gentlemen of general acquirements and education to form part of that commission. The Institute had not in their memorial made any representation as to who was to form the commission; they thought it better to satisfy themselves with merely asking to give evidence before it. He observed, that afterwards, at the Council Meeting, Dr. Robinson made a proposi-

tion that a sub-committee be appointed for inquiring into the most efficient means of promoting the establishment in Newcastle of a School of Mines and Industrial Science. Mr. Lowthian Bell, one of the members of the Institute, mentioned that that idea had been brought forward and had failed. The Duke of Northumberland had come very handsomely forward and made certain propositions, they were, however, such as the Institute could not carry out, and therefore they failed. And certainly, so far as their experience went, it would be extremely difficult, if not impracticable, to establish a University in Newcastle. Dr. Robinson then withdrew his motion, on the advice of Mr. Bell that it should stand over till Dr. Headlam had brought forward his proposition. That was the way in which the matter seemed to stand as regarded the Town Council of Newcastle. He (the President) had thought it desirable to mention this circumstance to the meeting, inasmuch as it became incumbent upon them to decide one way or another. They must either promote the establishment of a Mining College in Newcastle-upon-Tyne, or they must select the University of Durham. They had, on the occasion alluded to by Mr. Bell, despaired of being able to establish, (even with the munificent proposition of the Duke of Northumberland,) a Mining College at Newcastle, and he therefore fancied their only hope was with the University of Durham. It would be very desirable, however, if the members of the Institute would consider this very seriously before their next meeting, because he had been told that the Commission would be issued very shortly; and as, probably, he should be examined as to the views of the Institute respecting the locality of the Mining College, he should like to have it clearly understood that he was speaking the sense of the Institute, if he said that their opinion was in favour of the connection with the University of Durham. They had, in their proceedings, an outline of the mode in which the establishment of a Mining College was proposed to be arranged with the University. He made these observations at this time, with the view of directing their attention to this important subject. They would have a meeting on the fourth of next month, and he should like that the Institute should come to some decision at that meeting as to the plan which should be pursued.

Some conversation then took place with reference to Mr. Armstrong's paper, and it was agreed, that as Mr. Armstrong himself was still absent the discussion on the subject in question should be again postponed.

FINANCE COMMITTEE'S REPORT OF AUGUST, 1860.

Mr. BERKLEY said, the Finance Committee had not found themselves possessed with sufficient powers to examine the accounts which they thought it necessary to be examined, and therefore they had, in their report of August last, proposed certain alterations, giving the Finance Committee the requisite powers. He would, therefore, with the consent of the meeting, read the Report, which is printed in the "Transactions," Vol. IX., pages 65-6-7.

Mr. REID—We urge in this report that we should endeavour to make our proceedings more public—to make the fact known that there is such a society existing in Newcastle, and that more than once a month we should have some one here, so as to show what is doing in the Institute. We are gathering an extensive and valuable library, as well as models and specimens of different kinds, but they are only visible once a month.

The meeting having decided to go into the Finance Committee's Report,

The PRESIDENT said, the first recommendation was, that in future it should be made a rule that no duplicate copies be issued of any numbers of the "Transactions," unless by a written order from the Council, and that any alleged neglect on the part of the Post-Office in forwarding papers, or elsewhere, be fully inquired into.

Mr. BERKLEY then proceeded to move the Committee's first recommendation as a resolution :—"That in future it be made a rule that no duplicate copies of papers be issued to any of the members unless by written order direct from the Council, so that any neglect on the part of the Post-Office, or elsewhere, be fully enquired into."

After some conversation the resolution was put from the chair and carried unanimously.

The PRESIDENT said, the next recommendation was, "that in future, all loose parts of numbers of the proceedings be stitched together; that none be kept in sheets; and that two months after the whole were issued, they should be bound either in the permanent style as those already in stock, or in cloth, as the Council might decide." The first part of this recommendation was easily done. The second would cause them to bind the whole of the parts some time before they sold them. Was that desirable?

Mr. BERKLEY—It would cost the Institute a certain expense in binding.

Mr. CRONE—On the other hand they would be ready for sale if required.

Mr. DAGLISH—They would be equally ready for sale wrapped up.

Mr. REID—The object is to keep the property of the Institute together.

Mr. BERKLEY moved, in the first place, "that for the future all the loose sheets be stitched and stored," which was seconded by Mr. REID, and agreed to.

With regard to the question of binding the numbers

The PRESIDENT suggested—Why not stitch them together with a loose back?

This idea seemed to meet with general acceptation, and the Committee's recommendation was ultimately adopted in the following modified form: "That in future, all loose parts of papers be stitched together and stored, and that none be kept in sheets, and that two months after the last part of the volume is issued, the whole should be stitched together."

On the next three paragraphs of the report,

Mr. BERKLEY moved—"That heads be kept at the printing office, in a proper book for this purpose, showing the numbers and distribution of each part; and that the number of sheets entered to stock be carried to a ledger account under a proper head for each volume—the loose numbers being debited to the volume, and the sales and distribution credited; and that the Secretary take the requisite steps for carrying the above resolutions into effect."

This resolution having also been adopted,

The PRESIDENT called attention to the second part of the report, embodying the proposal to have a paid Secretary. He said he should be glad to have the assistance of any one, and said that proposal would meet his views entirely.

Mr. BERKLEY—It was the opinion of the committee that the enormous amount of work thrown on the President was not fair, and that the proposed Secretary would take the first part of the work off his shoulders. After the Secretary had looked over the reporter's notes, and put them into form, they might go to the President. It was not proposed by the committee to interfere with the present Secretary's duties.

The PRESIDENT—What shall we say about the appointment of a paid Secretary?

Mr. Berkley—Are the funds of the Institute sufficient for the purpose? You could not get a good Secretary under £100 or £150 a-year.

Mr. Reid—I would not name any figure. When it becomes known that the Institute are ready to appoint such a man there are some young members who would come forward and who would lay themselves out to work the thing to the best advantage. I think you will find it is only following in the wake of other societies to do it.

Mr. Berkley—Our intention was that Mr. Doubleday should continue. We have no wish to interfere with him at all.

Mr. Southern thought the whole matter should be left to the consideration of the Council.

Mr. Berkley said, the chief thing was as to the funds. If it was thought advisable to leave it till the passing of this year's accounts they would see what interest they got from the Stephenson fund. It might then be a subject for settlement. There might be a further statement as to how the funds were to be disposed of against the meeting in August. It was a subject of very great importance to the Institute, and perhaps it might be as well to leave it to the annual meeting to decide whether they would have it carried out. He proceeded to move—"That it be referred to the Council to consider and report to the annual meeting in August on the question of engaging a paid Secretary."

The President asked if the Council should not also take into consideration the subject of rooms, and arrangements for keeping the property of the Institute.

Mr. Berkley thought that should be a part of the resolution.

The meeting accordingly agreed to request the Council to report to the general meeting in August, the best means of carrying out the proposition with reference to a paid Secretary, and the subject of rooms and arrangements for the safe keeping of the Institute property.

The President said they then came to the following observation in the report:—"We cannot help saying that the arrangement with the Coal Trade Association, so far as it has gone in the infancy of the Mining Institute, has been a most beneficial one; yet still looking at the magnitude of the interests which will be discussed as the Society becomes older, as the growing necessity for publicity in all its proceedings becomes more felt, as well as the fact that it ought to a certain extent be a self-supporting institution, we feel prompted to the conclusion that that arrangement now demands the attention of the Council as to its permanence."

Mr. Berkley said that was included in the resolution they had just passed.

The President said they were under great obligations to the Coal Trade Association for allowing them to occupy the rooms without payment.

Mr. Reid said they knew they had the rooms for nothing, but they did not know what liberties they might take with them as regarded improvements and alterations. But as they got things gathered together they might want further arrangements; but they had not the liberty to alter the property as they might think fit, and the better show they made in that Institute the better they would succeed with the Mining College.

Mr. Berkley said the idea was to get rooms adjoining these as a museum and library, and keep the present room for lectures. The present library would be shortly filled—where then were they to put their books?

Mr. Southern thought it would be time enough to consider that when they required the room for the books.

Mr. Berkley said these matters can be brought before the Council when they consider their report to the Annual Meeting, which was agreed to.

The President said they then came to another suggestion—"That the books and accounts in the hands of the Treasurer, as well as all accounts, should be closed to an earlier period than hitherto, say 30th June in each year, and that the whole lie on the table from the 15th July to the Annual General Meeting in August, for the inspection of the members." He saw no objection to that suggestion.

A resolution embodying this recommendation was accordingly passed.

It was then agreed that the election of officers be postponed till next meeting, and that proper notice be given accordingly.

The President stated that it now became his painful duty to notice the great loss the Institute had sustained in the lamented death of their late Vice-President, Mr. Thomas John Taylor. It had been his melancholy duty, within a very short period, to have to notice the death of two of their Vice-Presidents, both gentlemen eminent in science and literature, both of whom, during their brief sojourn in this world, had done much, very much, few more than they had, towards the promotion of a system which, more than any other, had contributed to the social comfort, convenience, and prosperity of this, and, he might add, of future generations. The names of Mr. Robert Stephenson and of Mr. Joseph Locke

would go down to posterity as gentlemen who, though they did not originate, had aided most materially in the establishment of the system of railways, which had made such a revolution in the internal economy and celerity of transit in almost every country in the world. These gentlemen, though comparatively young in years, and in vigour of mind, have been taken from us by an inscrutable Providence, and we have very recently indeed had the melancholy duty to record the great loss which this Institute, in common with the public at large, have sustained. We have now to record the irreparable loss of a third Vice-President of this Institute, Mr. Thomas John Taylor, who, though he may not have moved in so prominent a sphere, as regarded the public at large, as the former two gentlemen, yet in the sphere in which he did move, in the locality in which his labours extended, and which was by no means of trifling extent, his career was equally eminent, useful, and successful; and as regards this Institute, his loss is most inadequately expressed by being said to be irreparable. In accordance with my duty as President, and with the assistance of our Secretary, Mr. Doubleday (who, as we all know, was upon very intimate terms of friendship with our late lamented Vice-President), I have drawn out a short memoir of the prominent features of Mr. Taylor's life, and of his labours in his profession, which I now take the liberty of laying before you, and which I feel is far beneath the merits of him to whom it seeks to honour.

MEMOIR

OF THE LATE

THOMAS JOHN TAYLOR, ESQ.,

VICE-PRESIDENT OF THE NORTHERN INSTITUTE OF MINING ENGINEERS.

By THE PRESIDENT.

The late Thomas John Taylor, in whose death mining science and enterprise, and this Institution, have so much to deplore, was born at Shilbottle, in the county of Northumberland. He was the eldest son of Mr. John Taylor, who, as a colliery agent to the Duke of Northumberland, was connected with coal mining generally. From an early age his son, Thomas John, showed symptoms of a delicacy of constitution, and also of that, which often accompanies a too fine organisation, the gift of remarkable abilities. He received the rudiments of his education at Ponteland, a village about five miles on the north side of Newcastle-upon-Tyne, and not far from the village of Newburn, which was the residence of the family of the Taylors for several years. At an early age he is said to have exhibited unmistakeable signs of the strong and comprehensive intellect with which he was endowed, and also evinced that strong attachment to field sports, as they are termed, which has characterised so many other singularly gifted men. Davy and Paley were both keen anglers; and, in after-life, Mr. T. J. Taylor probably remembered the achievement of playing a salmon to the death, or dragging a heavy pike out of the Tyne, with more pleasure than his youthful successes at school or university. When done with school, he spent some time at the University of Edinburgh. He there studied under Leslie, John Wilson, Jameson, and other leading men of that day, whose notice his talents attracted, and with whom he became a favourite pupil. It is remarkable that, in spite of the obstacles of delicate health and

great strength of imagination, he was through life a hard-working student, and, as a consequence, always noticed by men who were themselves studious.

Mr. Thomas John Taylor lost his father when about fourteen years of age, an event which put him under the guardianship of his uncle, Mr. Hugh Taylor, of Newburn, and subsequently of Earsdon, a gentleman well known as Chairman of the Coal Trade of Northumberland and Durham. Mr. John Taylor, who was himself connected with the Coal Trade, had, it is understood, always destined his eldest son, Thomas John, to mining pursuits. This wish of his father was complied with by his uncle and guardian, who then filled the situation of mining agent to the Duke of Northumberland, and who gave such a direction to the studies of his nephew as might be of most use to him as a viewer of collieries, and a practical, as well as theoretical, mining engineer. Young Taylor, in accordance with this view of his future life, directed his energies principally, therefore, to become a proficient in Mathematics, especially as applied to practical pursuits, as well as in Mechanics, in Mineralogy, in Geology, as the science was then developed by Jameson and others, and in Chemistry, as then taught by Hope, Davy, Wollaston, and the other leading men of that department at that era. In these branches of science his comprehensive mind and extraordinary power of application, which was its leading characteristic, soon enabled him to become well versed. Nor was this all. Those who were intimate with him knew that to the departments of knowledge above particularised, he by no means confined himself. Whilst at school and at the university, he had mastered the Latin language, and acquired a competent if not a critical knowledge of Greek; and to classical reading he was partial throughout the whole of his active and laborious career. When the topic on which he was conversing suggested an apposite quotation from some classical author, he rarely missed it, especially if its application partook of the ludicrous or witty. Nor had he recourse only, as has been the case with others remarkable for this habit, to those authors commonly put into the hands of a young man at school or university. With the more obscure and less read classic writers he was by no means unacquainted. He put the genius of Lucan on a level with that of Virgil; and esteemed the epigrammatic style of Tacitus before the more diffuse periods of Livy and Cicero. In fact, had his leisure allowed it, Philology would have been one of his most cultivated as it was always one of his most favourite pursuits. To trace the more modern dialects

up to the more remote tongues of antiquity, would have been to him, had he commanded time to follow it up, one of the most delightful of mental exercises, especially as connected with the remote history of the various races that now compose the living world. He had also paid great attention to Natural History properly so called, especially as connected with and bearing upon geological investigations and conclusions.

Such were the acquisitions which formed the basis or standard of the active life of Mr. Thomas John Taylor. They were certainly neither few nor unimportant; and he had almost bought them too dearly. When he had arrived at the period for entering upon the more toilsome business of life, his health showed symptoms of giving way. With his powerful frame and great muscular strength, his constitution did not accord; and so serious were the symptoms of delicate and impaired health at this period, that his medical advisers recommended a temporary residence in a warmer climate, and a voyage up the Mediterranean. This advice he adopted, and went to Malta for a short period of absence, which he lengthened by passing some time in Italy, and also in the south of France, in the vicinity of Bordeaux. This course seems to a certain extent to have re-established his health, though he always showed symptoms of liability to pulmonary attacks, as well as to quinsy, against which, through life, he had occasion to guard.

Mr. Taylor was, under the guardianship of his uncle, brought up as a colliery viewer. In this character he was first employed in the supervision of some of the smaller collieries of that period with which his relative was connected. He then undertook, after Mr. Thomas E. Forster, the management of Haswell Colliery, a large and successful coal mine, in the parish of Easington, in the county of Durham, in which his uncle was one of the principal partners. At Haswell, however, he did not long continue. His health, which was still somewhat precarious, appeared to suffer from his residence in that locality; and a change in the position of his uncle, Mr. Hugh Taylor, opened out for him a field of occupation more congenial to his habits of various application and multiform pursuit. At this time the late Hugh, Duke of Northumberland, died, and was succeeded by his brother, the present noble holder of the title and estates. By him Mr. Hugh Taylor was appointed sole commissioner of the estates, and to enable him to execute the onerous duties connected with such a position, he naturally sought the able assistance of his nephew.

Mr. Thomas John Taylor, as one of the results of this change, accordingly succeeded his uncle in the post of mining agent to the Duke. He had previously acted in the capacity of chief viewer for his Grace. Mr. Taylor had, from his early years, taken a deep interest in the progress and advancement of the coal trade of the North of England, to the history and statistics of which he paid great attention. This had obtained for him the friendship and confidence of the late Mr. Buddle, then one of the leading mining engineers of the North of England. Mr. Buddle's vast practical experience in all pursuits connected with coal mining led to his being extensively consulted on such subjects, and he, in turn, had frequent recourse to the geological science and mechanical and chemical knowledge of his young friend, Mr. T. J. Taylor, whose acquirements he well knew and entirely and fully appreciated. These varied acquirements, connected, as they were, with both the theory and practice of his profession, naturally led to Mr. Taylor's frequent employment in difficult and complicated mining cases; amongst others was a dispute between the Government and the Earl of Lonsdale as to certain rights of royalty, which involved several mining questions of great difficulty and intricacy. To settle such a question in a court of law was impossible. Arbitration by practical and, at the same time, scientific men was the only resource; and to Mr. Thomas John Taylor, in conjunction with some others of the principal viewers of the district, the settlement of the matter was accordingly left. The satisfactory manner in which this was effected led to his being consulted upon similar difficulties; and by the Welch coal owners especially he was often called upon for advice or adjudication where legal knowledge was of no avail, and where mining science and mining experience, combined with strong powers of mental discrimination and reasoning, could alone give hope of a satisfactory result.

Whilst engaged in these pursuits, his diligence in compiling scientific and statistical records was unremitting. Nothing was omitted, because nothing was unobserved that was worthy of observation. The consequence has been, that his indefatigable pen has enabled him to leave behind him numerous MS. volumes, containing records, calculations, remarks, and recommendations, on the various and recondite matters connected with coal and other branches of mining industry, the value of which it would be in vain to attempt to compute, so varied and so multiform are the subjects treated of. Amongst other points of interest, the history of coal mining in the North of England, where it had its origin, had early

attracted his attention; and such information as to the ancient methods of digging for and raising coal, as his assiduous research had enabled him to collect, he published in the shape of a Treatise, which takes date in the year 1843, and embodies in a condensed form the bulk of what is known as to the earlier practice of coal mining. On the occasion of the Archæological Society holding their annual meeting in this town, he read a Paper on the same subject, which forms part of the printed "Transactions" of the society.

As a coalowner, mining agent, and mining engineer, Mr. Taylor's comprehensive mind was necessarily engaged upon two collateral branches of engineering,—the construction of railways and river engineering; especially as the latter was directed to the improvement of tidal river harbours, and their adaptation to the purposes of a rapidly growing commerce. Of the phenomena of river currents, and their various effects upon the varied strata, of which their beds are composed, he had taken very early notice. Indeed he has been sometimes heard to say that he might date his attention to river engineering and his consideration of the natural laws which regulate the action of streams or river currents from his early days of angling, a sport of which he was passionately fond. He generally, however, contrived to combine with amusement the pursuit of useful knowledge. Few men ever possessed a more varied capacity for observation in every direction that was open to him. Such was the case in this instance. Whilst apparently engrossed with the trivial pursuits of a fly fisher, or an angler with the worm, he was at the same time gathering facts which, when occurring in large rivers, form the basis of all river engineering science. His knowledge of dynamics enabled him to calculate, under all circumstances, the forces of moving water; and the result was a long series of careful observations, and of calculations founded thereon, which were embodied in a succinct but most able treatise on the improvement of tidal harbours and river engineering generally. The amount of scientific knowledge, given in a condensed form in this lucid tract, can, of course, only be appreciated by those to whom the study is familiar. So clearly and graphically, however, are the natural phenomena upon which the scientific portions are based, described, and distinguished, that an ordinary reader may comprehend the principles to which they lead, without being able to test the precision and accuracy of the calculations upon which they are based. Of this tract, which was published about ten years ago, it may be safely said, that it not only exerted a material influence upon the discussions and

consequent measures as to the improvement of the river and harbour of the Tyne that have since taken place, but that, upon the general conclusions, therein developed the management and improvement of tidal harbours in general have been to a considerable extent based. That the subject is complicated, and, in many of its bearings, extremely intricate, must be admitted by all. To Mr. Taylor, however, this difficult and arduous branch of engineering science is indebted, probably, for some of its clearest ideas and least assailable conclusions. Having been unambitiously and unostentatiously put forth, they may have been less prominent to the public eye than treatises and lucubrations of less merit may possibly have been; but of their intrinsic value no candid inquirer into this difficult question can doubt.

After the formation of the body of Conservators, known as the Board of Commissioners for the River Tyne, their attention was naturally drawn to Mr. Taylor, as one whose practical as well as theoretic knowledge, as to the arduous duties that now devolved upon them, might be of great importance. He was, accordingly, consulted by them, on various occasions, on different points connected with the improved treatment of the River and Port of Tyne. In the plan and subsequent formation of the Northumberland Dock, he took a considerable share. In the projection and execution of the works now in progress at the mouth of the river his advice had also its weight; nor was anything of importance decided upon in this department, until his opinion was first ascertained. On the death of Commander Purdo, who was one of the original commissioners of the River Tyne, it was expected by most persons that he would be succeeded by Mr. Thomas John Taylor. In this, however, public expectation was disappointed. On being applied to, he declined to hold an office for which, in the opinion of all, he was eminently fitted. His apprehension appears to have been that his duties, as a River Commissioner, might, occasionally, have been found not to be compatible with some of the obligations which his various agencies entailed upon him. This with him was an insurmountable obstacle; nor would it cost him much to yield to dictates and considerations which the rectitude that ever governed his actions easily taught him were such as ought to be obeyed.

As a railway engineer he had not, very fortunately, this obstacle with which to contend; and, hence, in the case of the Border Counties' Railway he was not prevented from putting forth the whole energies of his mind to ensure success to an enterprise which, but for him, would pro-

bably have turned out one of those well-intentioned but ill-fated schemes, which seem only born to die. The project of this railway did not, from first to last, find much favour with the public. Its principal originator and talented advocate was never a slave, however, to public opinion, in this or in any other matter. Mr. Taylor thought differently; and he thought for himself. To those who knew him intimately it was not unknown that Mr. Taylor deemed that the real and great value of the locomotive steam engine and railroad, in a commercial point of view, resided in the power they possessed of expeditiously carrying ponderous articles, which could not have found a profitable transit through any other means. Acting under this conclusion, he looked less at the passenger traffic, which by ordinary calculators is made the primary consideration, than to the opening out of the seams of coal and the other mineral products, in which that district of country which borders upon the northern branch of the River Tyne and its tributary, the Reed, are known to be rich. That coal of good quality is associated with the carboniferous or mountain limestone of that part of the county, is a fact no longer doubtful; although its extent remains, and may, for some time to come, remain unascertained. It is also certain that iron ores of value abound towards the river Reed; although, hitherto, the expense of carriage has precluded their being worked to a profitable purpose. The completion of the Border Counties' Railway, now in course of formation, and amalgamated with the North British lines, will no doubt render these available, and it cannot be doubted that the power of cheaply obtaining supplies of the Plashetts coal must prove a valuable auxiliary to the prosperity of the manufacturers of Hawick and all that portion of the Scottish Border; and that, in time, the iron-stone of Reedwater will be turned to advantage. Mr. Taylor has, unhappily, not been spared to witness the success of a speculation which he tasked his powers so greatly to advance; those who survive him may, however, probably witness the period, when the traffic, and most especially the mineral traffic of this line of railroad, will, like that of most other lines, far exceed the original estimates of its projectors.

The last project to which the great practical talent and engineering sagacity of Mr. Taylor were applied was that for the drainage of that basin of coal along the northern bank and immediately underneath the bed of the River Tyne which is at present inundated with water, and which, having St. Peter's as its centre, will embrace a radius of six or seven miles every way. To minutely describe Mr. Taylor's plan for draining this basin, which was brought under the consideration

of Parliament during the earlier part of the present session, would require more space than can be afforded for that purpose. Its objects, and the means by which they were to be secured, were lucidly detailed and explained in the bill brought into the House of Commons, and in other explanatory documents drawn by the able hand of its originator and chief advocate. Like most other bills of a similar character it met with opponents, and since Mr. Taylor's lamented death it has been withdrawn, at all events for the present session of Parliament. To the principle upon which it is based, however, little or no opposition has been ventured. The time may possibly not have arrived for carrying it into execution. In some particular cases its operation might seem to press somewhat hardly upon individuals. But, as a general principle, the idea of a system of combined drainage must always be one of deep import to all concerned in raising coals, as well as to all owners of royalties having mineral coal as a portion of such royalty. Nor is it a question which, however little understood by the public at large, does not interest that public. Great as are the riches of England in the form of her coal seams, these seams are not inexhaustable. By the isolated method of working and draining collieries, which is now followed, it is quite undeniable that much waste of coal is involved. Every distinct colliery is under the necessity of leaving a barrier all round of considerable thickness and value. When the rest of the coal is taken away these barriers cannot be rendered available, and are therefore lost; and this loss, when calculated, amounts to a total startling in the extreme to persons unacquainted with the subject. It may be safely assumed, therefore, that, in merely enunciating this principle, and embodying in a bill the details necessary for securing the results, Mr. Taylor has rendered a most valuable service, not only to those interested in coal mines, but to the public at large, and that the time will arrive when that service will be appreciated.

This was the last considerable project in which he was engaged; many minor operations, however, of very great importance in their probable consequences, might be enumerated, in which his advice and suggestions were sought and acted upon by those most directly concerned.

To Mr. Taylor's reasonings and investigations, also, with regard to explosions in coal mines, so destructive to life, may be in some measure attributed the opinion, now becoming very prevalent amongst persons of all grades employed in coal mining, that without the safety-lamp there cannot be much safety for those employed in fiery coal mines. This Mr.

Taylor has shown in his essay "On Explosive Gas *in Sitû*," which is printed in Vol. I. of the "Transactions" of this Society. It follows from what is there laid down that no ventilation can guard the miner from those sudden irruptions of explosive gas which arise from his coming upon a cell or bag of gas in a highly condensed state, which, on being liberated, immediately expands and fills the mine, the first naked light that it meets exploding it as a matter of course.

Amongst the many subjects for regret arising out of the premature decease of this gifted man, it is to be deplored that, during his lifetime, he had prepared for the press and published so small a portion of his writings. It is understood that he has left behind him manuscripts on various subjects, not only connected with engineering, but with various departments of literature and general knowledge. In what state of completeness these may have been left cannot be at present stated; but it is earnestly to be hoped that they may not be finally lost to the world.

Mr. Taylor married, in 1839, Miss Eliza Taylor, a daughter of Thomas Taylor, Esq., of Whitley, and afterwards of Earsdon, whom he early lost after she had given birth to a daughter, who survives him.

At the period of his death he was mining agent to the Duke of Northumberland and to Lord Hastings, and had under his supervision the estate and coal mines of Stanley and Stella, belonging to Colonel Towneley, in this vicinity. He was a director of the North British Railway after its junction with the Border Counties Line, and lastly a Vice-President of this Society, to whose recent losses by death his premature demise makes another melancholy addition.

In fine, it may be safely said of the subject of this Memoir, that his accomplishments as a gentleman were fully commensurate with his virtues as a man. A ripe scholar, a good linguist, and well versed in a variety of scientific research, his conduct was distinguished by urbanity of manner, combined with integrity of purpose. Like most men who to power of intellect unite purity of intention, his judgments were sometimes stern, and his criticism occasionally severe; but so well was his keen perception of the character of others attempered by the amiable qualities of his own, that as he never made an enemy, so he never lost a friend, and such of human infirmity as fell to his own lot was only observed to be forgiven and forgotten.

He died, after a few hours illness, and without suffering, from rapid congestion of the lungs, at Bellingham, in Northumberland, in the fifty-first year of his age.

NORTH OF ENGLAND INSTITUTE

OF

MINING ENGINEERS.

GENERAL MEETING, THURSDAY, JULY 4, 1861, IN THE ROOMS OF THE INSTITUTE, WESTGATE STREET, NEWCASTLE-UPON-TYNE.

NICHOLAS WOOD, ESQ., PRESIDENT OF THE INSTITUTE, IN THE CHAIR.

The PRESIDENT said this was the regular meeting, but in consequence of the approaching meeting at Birmingham, the usual routine business only would be transacted. It was, however, also specially summoned for the election of officers of the Institute, in accordance with the general rules of the Society.

The following gentlemen were then elected members of the Institute, viz.:—Mr. Francis C. Gillett, Derby, Derbyshire; Mr. George Fowler, Moira Collieries, Ashby-de-la-Zouch, Leicestershire; Mr. John Kenyon Blackwell, 73, Gloucester Terrace, Hyde Park, London; Mr. William Henry Beckett, Pina, Wolverhampton, Staffordshire; Mr. Thomas E. Forster, 7, Ellison Place, Newcastle-on-Tyne; Mr. Maskel Wm. Peace, Solicitor, Wigan, Lancashire; Mr. John Lancaster, Hindley Hall, Wigan, Lancashire.

The PRESIDENT said there was a vacancy in the office of Vice-President, in consequence of the death of the late Thomas John Taylor, and he begged to propose Mr. Thomas Emerson Forster to fill the vacancy.

Mr. HALL seconded the motion, which was carried unanimously.

The PRESIDENT, after referring to the meeting to be held at Birmingham the ensuing week, which he expected would be a good one, said he had received a plan and paper from Mr. Thomas H. Watson, of Hawthorn Cottages, Forth Banks, of an underground engine, which did

not seem to differ from one of the engines working at Black Boy Colliery. It was a copy of a machine that was in use in America. The paper would be referred to the Council to say whether it should be printed or not. He would propose that Mr. Watson's communication be received, and that he be thanked for the same.

The motion being seconded, was agreed to.

A conversation ensued as to the arrangements for the meeting at Birmingham; after which the meeting broke up.

NORTH OF ENGLAND INSTITUTE

OF

MINING ENGINEERS.

ANNUAL MEETING, THURSDAY, AUGUST 1, 1861, IN THE ROOMS OF THE INSTITUTE, WESTGATE STREET, NEWCASTLE-UPON-TYNE.

NICHOLAS WOOD, ESQ., PRESIDENT OF THE INSTITUTE, IN THE CHAIR.

Mr. MARLEY, in the absence of the Secretary, read the minutes of the Council; after which the meeting proceeded to the election of new members.

The PRESIDENT said, that as it was proposed to print the proceedings at Birmingham in a separate volume, it appeared desirable that the names of the gentlemen elected members at the Birmingham meeting should appear in the "Transactions" of the regular meetings of the Institute. He would, therefore, propose that the names of these gentlemen be read over for the purpose of being inserted in the proceedings of this meeting.

The names of the gentlemen were then read as follows:—Mr. Charles Edward Appleby, Derby, Derbyshire; Mr. William Buxton, Staveley Colliery, Chesterfield, Derbyshire; Mr. Thomas Carrington, Jun., Derby; Mr. William Dunn Gainsford, Derby, Derbyshire; Mr. John Jackson, Derby, Derbyshire; Mr. Robert Heath, Newcastle-under-Lyme, Staffordshire; Mr. James Lindop, Bloxwich, Walsal, Staffordshire; Mr. John Brown, Cannock Chase, Staffordshire; Mr. Colin Napier, Westminster Colliery, Wrexham, Denbighshire; Mr. Henry Jackson, Astley and Bedford Collieries, Leigh, Manchester, Lancashire; Mr. Robert Aytoun, 3, Felton Row, Edinburgh; Mr. Thomas Knowles, Ince Hall, Wigan, Lancashire; Mr. James Darlington, Chorley, Lancashire;

Mr. Henry Dennis, Byn yr Owen, South Wales; Mr. Thos. Dunn, C.E., Winden Bridge Works, Manchester, Lancashire; Mr. Howard, Staveley Works, Chesterfield, Derbyshire; Mr. J. P. Hunt, Corngreaves, Birmingham, Warwickshire; Mr. William Bryham, Rose Bridge, Wigan, Lancashire; Mr. Thomas Livesey, Chamber Hall, Hollingwood, Bradford Colliery, Manchester, Lancashire; Mr. Joseph Harris Smallman, King's Hill, Wednesbury; Mr. Richard Barrow, Ringswood Hall, Chesterfield, Derbyshire; Mr. Silas Bowkley; and Mr. Jacob Higmore.

The Report of the Council was then read.

Mr. Boyd having read the Treasurer's Account, it was resolved that the same be adopted and printed.

The President said the first subject of importance which he would take the liberty of bringing before them, was the recent explosion at Monkwearmouth Colliery, owing to an alleged insufficiency of the Davy-lamp. It was of very great importance to the trade, and especially to to the lives of the workmen, that a clear understanding as to the safety of the Davy-lamp should exist. The explosion seemed to have taken place in a bord where the Davy-lamp alone was used. The explosion killed a man, and his lamp was found a short distance from him in a perfect state. The verdict of the coroner's jury was—"That the air inside of the lamp fired, and by a sudden jerking the flame came through the gauze, fired the gas, and so caused the deceased's death." It was a serious matter, if the lives of the workmen were dependent on a person using a safety-lamp being so careful as not to give it a jerk, or attempt to blow it out. He might state to the meeting that some years ago he made a great many experiments on the safety of the Davy and other lamps; the result of which was published in the first volume of the "Transactions" of the Institute in 1852. It was well worth the consideration of the members of the profession how far these lamps were perfectly safe. He had, therefore, thought it his duty to bring this circumstance before the Council, who resolved that it should be referred to the general meeting of the Institute. There seemed to be in some quarters a doubt whether the accident could have happened by the explosion of a lamp in a perfect state, or if the gas was the ordinary inflammable gas of the mine; and he thought it would be very desirable for the Institute to make some further inquiries. He had, therefore, in the Council, proposed that the subject should be brought before the general meeting, so that further steps might be taken to ascertain the facts of the case. He believed the evidence was very fully reported in the

Colliery Guardian of July 27th; and no doubt they could obtain from the Coroner a full statement of the evidence, as well as his official report.

Mr. ATKINSON said it would be well to appoint a committee; and he begged to move "That a committee be appointed to communicate with Mr. Smith, the viewer of the colliery, to ascertain all the particulars relating to the accident, and to make any necessary examinations either of the lamp or of the mine, that they may deem necessary to elucidate the subject." That would probably produce a report for the next meeting of the Institute.

Mr. GREENWELL seconded the motion.

Mr. DAGLISH said that Mr. Smith might be requested to give them a paper on the subject.

Mr. ARMSTRONG said it would be well for the request to be made by letter from the President.

Mr. GREENWELL said if Mr. Smith and the gentlemen forming this committee were to act together, it would not compromise any person. There was one point as to the gas itself. They should give the committee power to get the gas analyzed. There might be something in the composition of the gas that caused the explosion through the meshes of the lamp.

Mr. ATKINSON agreed in the propriety of getting the gas analyzed.

It was then put to the meeting, "That the President be desired to communicate with Mr. Smith, and arrange with him as to the best way of bringing the subject before the Institute." This was carried by show of hands.

The PRESIDENT said the next question which he had to bring before them was that of the Mining College. The report of the Council presented to-day first referred to what had previously been done, then as to what had recently taken place, namely, the Commission which had been appointed by Parliament to enquire into the constitution and management of the University of Durham. If gentlemen had seen the Act of Parliament appointing a Commission, they would find that it included the promotion and cultivation of practical knowledge, as well as of divinity. The Institute (as was stated in the report) had presented a memorial to the Home Secretary—the substance of the prayer of which was, that they should be heard by evidence before the Commission. It was proposed to lay before the Commission such evidence as he

trusted would induce them to incorporate with the University, a practical Mining College. In the Proceedings of the Institute the members would see the sort of arrangement that was proposed to be made with the University. This had been accomplished by the late Mr. Thomas John Taylor and himself. He supposed every gentleman was conversant with the arrangement proposed. The Council recommend that the President, with Mr. John Thomas Woodhouse and Mr. Isaac Lothian Bell, be appointed to give evidence before the Commission, with power, if they think necessary, to call in any members of the Institute. He now submitted this proposition to the meeting for their approval.

Mr. Potter said, he heartily responded to this proposition. The President had already paid great attention to the subject, and it could not be in better hands, than in the gentlemen proposed.

Mr. Boyd said, there was a necessity for making a representation from this Institute on one point. It had been said that some portion of the funds now belonging to the Durham University were to be transferred to the University of Oxford or Cambridge. If there was any such intention, the opportunity should now be embraced of having these funds retained, if possible, for the use of the Mining College.

The gentlemen named were then appointed.

The President said, the next subject was the proposed connexion with the Natural History Society. It seemed very desirable that there should be some arrangement made to deposit in the museum of that society the specimens belonging to this Institute, so that strangers might see the whole at one glance. There would also be the advantage of having a person in the Natural History Museum to show them. The arrangements were not yet finally concluded; he therefore proposed that the negociation with the Natural History Society be continued, and that the Council report to the general meeting as early as possible. Agreed to.

The President said, the appointment of a Secretary, as recommended in the Finance Committee's report of last year, was the next business before the meeting. Their proposed connexion with the Natural History Society might lead to some changes, and the Council had, therefore, passed this resolution:—"That the office of secretary requires revision, so that all the duties may be efficiently performed, especially such as are not included in the duties of the present secretary."

Mr. Berkley, one of the Finance Committee, moved, "That the Council take the necessary steps to appoint a secretary, defining his duties and the salary of his office, and to nominate an efficient person, and that their report be brought before a general meeting of the Institute."

Mr. Tone—You assume that the office requires to be revised? If the curatorship of all your specimens is put into the hands of the Natural History Society you will not have much work for your secretary.

The President—There would, in that case, be other duties supplementary to those performed by your present secretary. Then the question arises whether for the ordinary duties of the office you should retain the present secretary and obtain the assistance of another person to perform the supplementary duties, or whether you should have one secretary to perform the whole of the duties. This had scarcely been sufficiently considered. If you gave the Council power to fix the duties the whole subject could be discussed at a future meeting of the Institute. He would beg to add, that on the subject being discussed by the members of the Council at their last meeting, he (the President) stated that Mr. Doubleday, who was unfortunately from home for the benefit of his health, had written to him a letter stating that if the retainment of his services was inconsistent with any arrangement that was thought desirable, he would place his resignation in his (the President's) hands to be used as the Council thought proper.

Mr. Marley seconded the motion of Mr. Berkley.

Mr. Potter said, the former resolution would suit the case better. The Council had not had sufficient time to discuss the subject, or to ascertain whether Mr. Doubleday could not take a more active part than he had hitherto done. Mr. Doubleday had many qualifications, but he had not devoted as much time to the Institute as was desirable, so that much of the work had been placed in the President's hands. He (Mr. Potter) preferred that the whole subject should be referred to the committee before they nominated.

Mr. Tone said, it would not be right to ask Mr. Doubleday to perform more duties without giving him a larger salary. He begged to second Mr. Potter's amendment.

On a show of hands the original motion was carried.

The President said, the next matter was the proceedings at the Birmingham meeting. The members of the Institute who visited Birmingham had been received in a way they could scarcely have expected,

and the step taken, of having occasional meetings of the Institute in the different localities was highly applauded. Several papers were read, sufficient in fact to constitute a volume, and highly important discussions took place. It was thought desirable that the proceedings at Birmingham should be printed in a separate volume. He thought that this would be the best arrangement, inasmuch as it was the rule of the Institute that all papers should be before the members a month before they were discussed. The discussion at Birmingham necessarily took place immediately after the reading of the papers. Two or three hundred people were present, and a good many could not hear the papers read so clearly as to enable them to take part in the discussions, and impromptu discussions on intricate scientific questions was not the best mode of elucidating the different subjects. If the papers were printed as a separate volume, and sent in that state to the members, the further discussion might be taken at some future meeting, to be specially appointed for that purpose, and embodied in the supplementary volume.

Mr. Greenwell said, he was glad it was proposed to print the papers in a separate volume, and he thought as they had been received with such great civility and respect they should print a few extra copies to present to the Mayor of Birmingham and others who had treated them so well.

The President said, that was a very proper suggestion. The Mayor and other gentlemen had done them great honour, and there were several other gentlemen who had thrown open their works to them, who were well deserving that compliment.

Mr. Boyd seconded the motion, and said it would be a substantial vote of thanks.

The motion was carried unanimously.

Mr. Daglish said, there was one subject which he would like to bring forward, viz., the propriety of having an increased number of vice-presidents. There were many gentlemen living in other parts of the country who were not able to attend the council meetings whose countenance was of great importance.

The President—You must give notice of such a resolution, and it would then have to be discussed at a future meeting.

Mr. Atkinson said the hands of the Institute would be strengthened by such a step, it would cause gentlemen of great eminence to take an interest in the Institute.

Mr. Armstrong suggested that the appointment of more vice-presidents would tend to dilute and weaken the honour.

Mr. Marley thought they would gain strength by an increase of numbers.

Mr. Bell said he was led to think that the office of vice-president was an honour; if they conferred honour on gentlemen who had done them no service, he thought that was scarcely a right principle to go upon.

Mr. Atkinson said he never thought of selecting people who had done nothing.

The subject then dropped.

Mr. Greenwell suggested that there ought to be some improvement in the method of getting up the diagrams. He found that there was a want of uniformity in the colouring. In one map the coal was coloured black, and in another it was coloured pink. He thought that all the geological maps should be coloured in accordance with the maps of the ordnance survey.

The President thought this was a very excellent suggestion. All the maps should properly come through the hands of the Council as well as the papers. Such an uniformity of colouring could, therefore, be very easily enforced, but he apprehended it would only be necessary to adopt the rule and gentlemen producing maps or plans would readily conform to such a very obvious improvement in the illustrations.

The motion having been seconded was carried by show of hands.

After some conversation respecting a bust of the late Mr. T. J. Taylor which had been brought into the room,

The President directed the attention of the meeting to a safety-lamp composed of the new metal, aluminium, which was not liable to corrode, and which appeared worth their consideration, as an excellent quality of material for a safety-lamp.

Mr. Bell, who presented the lamp, said that probably the cost of the material would be something like two shillings and sixpence or three shillings. He thought it was worthy of a little notice. There was one particular property he would mention, and that was its power of absorbing a large quantity of heat, the specific heat of aluminum being very high, so that it might be long exposed to heat before it became red hot. Though the melting power was some degrees below that of silver, if they put silver in one crucible and aluminum in another, they would find

the aluminum would be longer in melting than the silver. Then it was also incorrodible. Another property was, its not obstructing so many rays of light. Iron became black much sooner than aluminum. By mixing with it three per cent. of copper, they would get it strong enough. Any member might take it to the pit, and submit it to any trial he liked.

Mr. Atkinson said it might be tested at the same time with Mr. Hall's lamp at the Ryhope Pit; which was arranged.

The officers for the ensuing year having been elected, the meeting then broke up.

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